# DOMESTIC SEWAGE TREATMENT BY UNDERDRAINED FILTER SYSTEMS

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# DOMESTIC SEWAGE TREATMENT

# BY

# UNDERDRAINED FILTER SYSTEMS

by

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INDEX

# LIST OF TABLES

List of Tables (Continued)

# LIST OF APPENDICES

## ABSTRACT

It is concluded, as a result of a 3½ year study of underdrained sand filters, that such filters are an effective alternative to conventional tile fields for sewage disposal.

Removal of Biochemical Oxygen Demand and Suspended Solids generally averaged over 90%. Phosphorus removal by the sand was approximately 30%; the addition of red mud to the filter beds increased phosphorus removal to over 70%.

# 1.0 INTRODUCTION

According to the 1971 Census (1), about 25% of the dwellings in Ontario are on private sewage disposal systems. The Ministry of Treasury, Economics and Inter-Governmental Affairs had approved (2) over 44,000 new lots for residential or other development in unsewered areas of the Province in the year 1970. In the U.S.A. (3) one third of the liquid domestic wastes or about 3,000 MGD (135 $m^3$/sec) are disposed of by private on site subsurface absorption systems and roughly one fourth of the new homes are being constructed with private disposal systems (4).

Septic tank with tile field continues to be an acceptable means of sewage disposal. However, in the areas where conventional tile field cannot be installed, septic tanks with sand filter are generally considered to be an effective device as an alternative for the disposal of household waste.

The specification by Salvato (5) for filter media calls for a clean sand having an effective size between 0.3 mm and 0.6 mm and a uniformity coefficient of not greater than 3.5.

The Housing and Home Finance Agency (6) recommends an effective size of 0.25 to 0.50 mm and uniformity coefficient of not greater than 4.0.

The Ohio Department of Health (7) specifies sand with effective size between 0.35 and 0.50 mm and uniformity coefficient not greater than 3.0.

According to Fair and Geyer (8) sands having uniformity coefficients between 1 and 5 will have practically the same hydraulic characteristics provided the effective size of the sands is the same.

Material with rigid specifications as mentioned above is often difficult to obtain in Ontario.

It was decided to use the widely available sands classified at the gravel pits as "asphalt" sand, "block" sand, "medium" sand and "concrete" sand, etc. Effective sizes between 0.15 and 2.5 mm and the uniformity coefficient between 1.2 and 4.4 were considered to be acceptable for this program. After 4 months operation, however, filter medium of 0.15 mm and 0.19 mm in two of the beds which had clogged was replaced by sand with effective size of 0.24 mm and uniformity coefficient of 3.9. Also in one filter bed "red mud" was used as chemical additive for observing its effect in removal of phosphates. The red mud is a waste by product of bauxite purification process and contains compounds of calcium, alumium and iron. (Appendix I).

## 2.0 LOCATION

The experimental facilities were constructed on Provincially owned land at the Whitby, Ontario Hospital. Domestic sewage from dwelling units occupied by the hospital staff was used for the studies.

There were eight houses and a comfort station not connected into the hospital sewage system but instead, their sewage was diverted to flow to a septic tank system as shown in Figure 1.

The residents of these houses were full time hospital employees. Some of the residents were shift and some were daytime workers. The quality of the sewage is similar to that of a small community of residents of various ages and of various social-economic backgrounds.

The site of the test facilities was located in the farm area of the hospital, situated north-west of the intersection of Victoria Street and Farm Road and close to the septic tank system.

## 3.0 BUILDING

A timber building with plan dimensions of 11.0m x 3.7 m (36 ft x 12 ft) and with a central tower, was erected. The building was equipped with electrical and water services. The pipe lines necessary to carry the sewage from the septic tank to the building and effluent from the building to the septic tank, as well as the electric cable for operating the pump in the septic tank, were installed.

Six filter boxes, three on the north and three on the south, are located outside and adjacent to the building.

Figures No. 2, 3, 4 and 5 show the details (Appendix II).

## 4.0 PROCESS OUTLINE

The sewage was pumped from the dosing chamber of the septic tank into overhead holding tanks, (Fig. 6). From there it discharged by gravity downwards through regulating valves and measuring devices into the six dosing tanks. These tanks were provided with electrically operated valves which permitted discharge of sewage at the required frequency onto the corresponding filter beds. The beds contained filter media of different types and sizes. The treated effluent after quantity measurement, was discharged into the tile field through the distribution chamber. The entire system was so arranged that the quantity of sewage could be varied to load the filters. Moreover, samples of the sewage and the treated effluent from each filter could be collected. The samples were sent to the Public Health Laboratory for bacteriological analysis and to the Ministry of Environment Laboratory for chemical analysis.

## 5.0 PLANT

### 5.1 Septic Tank

The septic tank (Figure 7) was made of poured-in-place concrete. It consisted of two retention compartments and a siphon chamber. The first compartment had a length, width and liquid depth of 2.6 m, 2.0 m and 1.2 m (8.5 ft., 6.5 ft., and 4.0 ft.) respectively. The second compartment had corresponding dimensions of 1.2 m, 2.0 m and 1.1 m. The total capacity of the septic tank was to hold 8,900 l (2,000 gal.) of sewage.

The siphon chamber had dimensions of 3.5 m x 2.0 m (11.5 ft. x 6.5 ft.) wide and was originally provided with a 10.2 cm (4 in.dia.) siphon discharging into a distribution chamber for the tile field. The siphon was removed and the height of the out-flow pipe raised to 36.8 cm (14.5 in.) for increasing the capacity of this chamber. The sewage pump had been installed in this chamber. The flow rate and the quantity of sewage collected over continuous 30 hours was measured. The volume collected in 24 hours was 6,350 l (1,400 gal.).

5.2 Pump

The sewage pump was a 2 horsepower, 220v., 1740 r.p.m. It operated on float control to start when the level of sewage reached a certain height and cut out when it reached the low level in the sump or when the overhead tank in the building was full. The automatic cut off arrangement protected the pump from running dry, also preventing overflow from the overhead tanks.

A counter in the electric circuit indicated on the panel the number of times the electric pump operated.

5.3 Overhead Tanks

There were two 1140 l (250 gal.) each overhead tanks connected to their outlets through valves into a common discharge pipe. Sewage from the pumping chamber of the septic tank passed through the flow meter located at the ground floor, entered at the top of the overhead tank. The float control for the high and low level in this tank controlled the operation of the sewage pump. The outlet from the tanks was provided with an electrically operated valve in addition to the manually operated valves. An overflow pipe, with a connection for draining and cleaning the tanks when necessary, permitted return of sewage to the pump chamber of the septic tank.

5.4 Proportioning Devices

Proportioning device consisted of a galvanized iron tank 45.7 cm x 45.7 cm x 25.4 cm (18 in. x 18 in. x 10 in.) deep with tipping bucket arrangement for dividing the flow

into two equal volumes in the two pans of the tipping bucket. There were nine tipping buckets located on the second floor each provided with valves and connecting pipe work to permit varying the distribution of the quantity of the sewage for changing the loading rates for the filters, Figure 7.

5.5 Dosing Tanks

There were six 1140 l (250 gal.) dosing tanks each provided with motorized valves in addition to the manually operated valves. The sewage from the tipping buckets could be stored in these tanks for dosing at the desired frequency, programmed with the motorized valves or allowed to pass through directly as a dribble flow to the filter beds. The motorized valves could be controlled by an electrically operated timing device, Figures 3 and 4.

5.6 Filter Boxes

There were six rectangular filter boxes. They were 3.7 m x 3.0 m x 1.2 m (12 ft.x 10 ft. x 4ft.) deep made up of 1.9 cm (0.75 in.) plywood. Inside each box plastic sheet was used as a lining material, Figure 3.

On the bottom of each box were two 2.4 m (8 ft.) lengths of perforated collector pipe, joined by a header. The outlet pipe from the box entered the building at the floor level and the effluent discharged into a tipping bucket. The quantity of sewage flowing out of the bed was measured. Above and around these collector pipes to a height of 15 cm (6 in.) from the bottom was 2.5 cm to 4 cm (1 in. to 1½ in.) crushed

stone. This was followed by 0.76 m (30 in.) of the filter media. Above that was 5 cm (2 in.) of crushed stone, on which rested the three perforated distribution pipes 2.4 m (8 ft.) long with a header and connected to the dosing tank. These distributor pipes were surrounded by crushed stone. The box was then covered with top soil.

The filter media in the boxes had the following characteristics during Period I.

| | Bed No. | $D_{10}$ mm | $C_u$ | "K" cm/sec. |
|---|---|---|---|---|
| "Asphalt"Sand | 4 | 0.15 | 2.8 | $2.19 \times 10^{-2}$ |
| "Concrete"Sand | 1 | 0.19 | 4.4 | $3.61 \times 10^{-2}$ |
| "Block"Sand | 2 | 0.30 | 4.1 | $9.0 \times 10^{-2}$ |
| Foundry Slag | 3 | 0.60 | 2.7 | $3.36 \times 10^{-1}$ |
| Fine gravel with sand | 5 | 1.0 | 2.1 | $9.6 \times 10^{-1}$ |
| ¼" gravel | 6 | 2.5 | 1.2 | $4.84 \times 10^{0}$ |

The filter beds Nos. 2, 3, 5 and 6, since installation had been in use continuously. The beds Nos. 1 and 4 containing sands with effective sizes of 0.19 mm and 0.15 mm, respectively, which however, had clogged after about four months operation, were shut down and the sand replaced. The filter media characteristics for the six beds, as in operation for Periods II, III and IV are shown in the following table.

| | Bed No. | $D_{10}$ mm | $C_u$ | "K" cm/sec. |
|---|---|---|---|---|
| Medium Sand (with red mud) | 1 | 0.24 | 3.9 | $2.6 \times 10^{-2}$ |
| "Block" Sand | 2 | 0.30 | 4.1 | $9.0 \times 10^{-2}$ |
| Foundry Slag | 3 | 0.60 | 2.7 | $3.36 \times 10^{-1}$ |
| Medium Sand (without mud) | 4 | 0.24 | 3.9 | $2.6 \times 10^{-2}$ |
| Fine Gravel with Sand | 5 | 1.00 | 2.1 | $9.6 \times 10^{-1}$ |
| ¼" Gravel | 6 | 2.50 | 1.2 | 4.84 |

5.7 Collector Tipping Buckets

For measuring the quantity of effluent from the collectors, each filter box had a tipping bucket similar to those mentioned before. These were located at the ground floor. The measured effluent discharged into the 10.2 cm (4 in.) drain pipe connected to the distribution chamber adjoining the septic tank, and then flowed into the tile field.

## 6.0 OPERATION

The plant, with necessary calibrations, adjustments and repair of leaks had been in operation since September 1969 to date. Samples of the septic tank effluent and filtered effluents were delivered to the laboratory for analyses. Records were maintained for the amounts of fresh water used in the residences and the sewage pumped from the septic tank pump chamber to the overhead tank. Daily readings were observed from the counters attached to the tipping buckets to determine the quantities of sewage going in as well as that discharging out of each filter bed.

The chemical and bacteriological analysis of 24 hour composite samples of septic tank and filter bed effluents were carried out by the laboratory for the various indicators to determine the degree of treatment of the waste. A typical analysis is shown in Table I. These indicators were BOD, COD, Nitrogen as free ammonia, organic nitrite and nitrate, phosphates, solids suspended and total, surfactants as MBAS and coliform total and fecal. In addition, observations for temperature, pH values and dissolved oxygen content were recorded. Analysis of samples of raw sewage before discharging into the septic tank are given in Table 2. These are of composite from grab samples collected from the manhole nearest the septic tank, on three consecutive days for a period of 1½ hours each.

Observations for the average amount of water used per capita-day in the residences from 1969 to 1973 is given in Table 3.

The statistical analyses (9) of laboratory results for the effluents is shown in Tables 4 to 37.

An increase in the amount of sewage collected in the septic tank as compared to the amount of water used was observed. It was concluded that the increase was due to seasonal rise in the water table causing excessive infiltration, aggravated by cracks in the sewer line. The eaves troughs, which had originally been discharging rain into the sewer lines, were disconnected.

During the summer months, the amount of sewage collected was far less than the amount of water used as recorded on water meters. That was apparently due to the water used in the sprinklers for the backyard gardens and also due to losing some water through possible cracks in the sewer lines.

Filter beds 2, 3, 5 and 6 operated continuously without any serious problems. Filter beds 1 and 4, however, with filter media of $D_{10}$, 0.19 and 0.15 mm respectively, after four months trouble free operation, showed signs of flooding and overflowing early in February 1970. After intermittent operation and running at reduced rate, they were shut down in July 1970.

Filter media in beds Nos. 1 and 4 was replaced by sand with effective size of 0.24 mm and uniformity coefficient of 3.9. A portion of the sand in bed No. 1 had been mixed with "red mud" obtained from Alcan's mining operations in the Province of Quebec.

The septic tank was pumped out in December 1970 and again in April 1972 when the pump was overhauled. There were no

major maintenance problems excepting at times plugging of waste influent lines, breaking of the pivots of some of the tipping buckets or counters sticking.

6.1 Sewage Loading Pattern for Filter Beds

The operation of the system from September 1969 to March 1973 had been divided into four distinct periods as follows:-

| | | | |
|---|---|---|---|
| Period I | Sept. 28th. 1969 | to | July 23rd. 1970. |
| Period II | July 27th. 1970 | to | March 2nd. 1971. |
| Period III | March 3rd. 1971 | to | November 17th. 1971. |
| Period IV | Nov. 18th. 1971. | to | March 12th. 1973. |

For Periods I, II and III, the filter beds were loaded in the manner sewage effluent would be discharging, from the septic tank into the soil, commonly known as the trickle or gravity flow. The rate initially used was 49 $l/m^2$ (1 $gal/ft^2$) of filter area per day. In Period II it was increased to 73 $l/m^2$ (1.5 $gal/ft^2$) per day for some of the filter beds on different dates. All the beds were loaded on the average at 73 $l/m^2$ (1.5 $gal/ft^2$) per day during Period III.

For Period IV the loading pattern was changed. The septic tank effluent was discharged into the filters, after collecting it in the feed tanks, through the automatic programmed timing device, every six hours. This procedure offered longer resting intervals in between dosings as would be in the case of systems using syphons or a pumping device. The loading rate was maintained at 800 l (180 gal) per day, i.e. 73 $l/m^2$ (1.5 $gal/ft^2$) of filter area per day for all the beds as in Period III. The analysis of septic tank effluent for the four periods separately and for the entire period of operation, is shown in Tables 16 and 17 and Table 37 respectively.

6.2 Filter Bed No.1

$D_{10}$ = 0.19 mm. $C_u$ = 4.4

Filter bed No. 1 was put into regular operation on October 6, 1969 with a loading rate of 49 $l/m^2$ (1 $gal/ft^2$) per day. Samples of the effluent were collected after 24, 48 and 96 hours. These showed a good reduction of suspended solids; the values being in the range of 1.2 to 1.6 mg/l. The BOD values in the initial two samples, however, were 22.5 and 43.5 mg/l. The nitrate was less than 0.1 mg/l N and the free ammonia was 6.6 mg/l N or less. In subsequent samples there was a significant increase in the nitrate content and a decrease in the BOD. The system appeared to be settling down in about 2 weeks time.

After about 3½ months steady operation, the dissolved oxygen content in the effluent, which had been in the range of 2 to 3 mg/l dropped to 0.72 mg/l and continued generally so thereafter between 0.6 and 1.0 mg/l oxygen, more often near the lower limit. There was a gradual decrease in the nitrate content and increase in the BOD. This indicated that the system was tending to become anaerobic with the possibility of clogging of the filter media at this sewage loading rate.

The filter bed after 4½ months of operation showed signs of flooding and the sewage started overflowing in mid-February 1969.

Two days rest period did not improve operation of the system. However, when the sewage feeding rate was reduced to 24 $l/m^2$ (½ $gal/ft^2$) per day after one week rest period there appeared to be a recovery in the system as the nitrate content

increased from less than 1 mg/l for 3 consecutive weeks to a range of 2.3 to 11.0 mg/l and the maximum value for BOD and suspended solids of 0.8 and 8.4 mg/l respectively.

At the reduced sewage loading rate 24 $l/m^2$ (½ $gal/ft^2$) per day, there appeared to be no problem with performance of the system. On increasing the rate to 49 $l/m^2$ ( 1 $gal/ft^2$) per day after about 2 months operation at ½ rate the quality of the final effluent deteriorated. It became apparent that the filter could not handle the waste at 49 $l/m^2$ (1 $gal/ft^2$) per day sewage load.

The examination of the bed showed that directly under the top soil cover, above the gravel was anaerobic sewage mixed with black sludge and live organisms. The sludge was more concentrated around the distributor pipes. It appeared that the upper layer of the sand had clogged since, during raking and shoveling of the gravel, a break through the clogging interface occurred, resulting in the rapid discharge of waste through the sand.

The filter media had treated the waste to produce an effluent with BOD and suspended solids for 85% of the time equal to or less than 7.0 and 5.0 mg/l respectively (Tables 4 and 5). The values of free ammonia (N) however remained as high as 17 mg/l, indicating that the nitrification process did not approach completion.

The useful life of the system when loaded at 49 $l/m^2$ (1 $gal/ft^2$) per day was limited to approximately four months. At half of this or at lower loading rate the system could have operated satisfactorily for a much longer time.

Filter Bed No. 1 (New)

$D_{10}$ = 0.24 mm $C_u$ = 3.9

The filter medium of Bed No. 1 was replaced by sand of effective size 0.24 mm., and uniformity coefficient of 3.9. In addition, the sand had been mixed with "red mud" obtained from Alcan Co. Ltd., Province of Quebec, in a hand cement mixer to provide approximately 4% of red mud in the sand. This mixture was put on top of 33 cm (13 in) sand as a layer 20 cm (8 in) deep and on top of this again was the filter sand. The details of the filter bed and the analysis (physical and chemical) of red mud is given in Appendix I.

The waste feed at the rate of 24 $l/m^2$ (½ $gal/ft^2$) per day was applied for 1½ months before increasing it to 49 $l/m^2$ (1 $gal/ft^2$) per day. In November 1971 the loading pattern was changed to a programmed six-hourly sewage loading. The values of the various parameters are given in Tables 4 and 5.

The BOD values in 85% of the samples during the three periods of operation were equal to or less than 5.5, 8.4 and 3.9 mg/l respectively. The corresponding values for suspended solids were 1.5, 1.5 and 6.0 mg/l. Considering three years operation, 1970 to 1973, (Table 31) BOD and suspended solids in 85% of the samples were equal to or less than 6.4 and 3.6 mg/l respectively. The phosphate concentration was lower than 2.7 mg/l P.

6.3 Filter Bed No. 2

$D_{10}$ = 0.30 mm $C_u$ = 4.1

Filter Bed No. 2 was put into operation on October 6, 1969 with a feed rate of 49 $l/m^2$ (1 $gal/ft^2$) per day. The BOD and suspended solids were reduced to 6.2 mg/l and less than 1.0 mg/l respectively after 48 hours operation. It was after about a week that the oxidation of nitrogenous components started showing up.

The filter bed continued operating at 49 $l/m^2$ (1 $gal/ft^2$) per day till October 26, 1970 when the feed rate was increased to 73 $l/m^2$ (1½ $gal/ft^2$) per day. In November 1971 the bed was put on timer arrangement receiving septic tank effluent 4 times a day. The values for the various parameters for the four periods are shown in Tables 6 and 7 and overall in Table 32.

The values for BOD during the initial three periods in 85% of the samples were equal to or less than 7.0, 9.5 and 9.4 mg/l. The corresponding values for suspended solids were 3.1, 3.5, 7.0 and 8.1 mg/l. The free ammonia which had a value of 15 mg/l N during the first period was reduced to 9.0, 2.8 and 0.8 mg/l N in three subsequent periods.

The values for BOD and suspended solids on the basis of the entire period were equal to or less than 8.0 and 4.9 mg/l respectively in 85% of the samples. (Table No. 32)

6.4 Filter Bed No. 3

$D_{10}$ = 0.6 mm $C_u$ = 2.4

Filter bed No. 3 containing foundry slag as filler media was brought into regular operation on October 7, 1969

at the feed rate of 49 $l/m^2$ (1 $gal/ft^2$) per day. The BOD after 24, 48 and 96 hrs. of operation was 82, 40 and 12.4 mg/l respectively. The corresponding suspended solids were 31, 11 and 11.2 mg/l. After eight days operation the BOD and suspended solids were 4.8 and 1.2 mg/l respectively. The nitrification process was slow and the nitrate content was less than 0.1 mg/l till after 2 weeks of operation. The free ammonia during that period was high in the range of 33 - 36 mg/l N. After 1½ months of start of the operation, the nitrate concentration increased to 38.6 mg/l N and the ammonia concentration dropped to 6.0 mg/l N.

The feed rate was increased to 73 $l/m^2$ (1½ $gal/ft^2$) per day on October 26, 1970 and was changed to six-hourly timed loading pattern from November 18, 1971 at the same daily flow rate.

The values for the various parameter for the four test periods are given in Tables 8 and 9. It could be observed that there was no significant difference in the values of BOD as determined in 85% of the samples collected during the first three periods. These were 8.6, 8.1 and 8.8 mg/l. The corresponding values for suspended solids were 3.5, 2.4 and 2.9 mg/l. During the last period BOD and suspended solids were 3.5 and 8.2 mg/l respectively. The values considering the entire period were BOD 6.6 mg/l and suspended solids 5.0 mg/l or less in 85% of the samples respectively, (Table No. 33).

6.5 Filter Bed No. 4

$D_{10}$ = 0.15 mm $C_u$ = 2.8

The filter bed was put into operation on October 6, 1969 at the sewage loading rate of 49 $l/m^2$ (1 $gal/ft^2$) per day. However, since there appeared to be some leaks in the outlet from the filter box, it had to be shut down for repairs and restarted on October 21, 1969. The initial few samples had low BOD (7 - 8 mg/l) but relatively high suspended solids. The suspended solids contained appreciable amounts of inorganics (18 - 50 mg/l), possibly as fine sand and clay particles. By the end of the month, however, the values for BOD and suspended solids had come down to 6.4 and 3.8 mg/l respectively. The nitrate content was less than 0.1 mg/l N till 2 weeks from the start of the system when it started to increase. The value approached to 13.6 mg/l in the following two weeks. The values of free ammonia continued to remain very high during operation of the system at this loading rate. These were up to 15 mg/l N in 50% of the samples and up to 21 mg/l N in 85% of the samples.

During the three month period effluent from the bed had been showing dissolved oxygen in the range of 2.8 to 5.0 mg/l. Afterwards the D.O. started decreasing and the values were often near 1.5 mg/l. This was an indication that the system was likely to become anaerobic at this loading rate with the possibility of clogging of the filter media.

The bed on February 6, 1970 showed signs of ponding of sewage on the surface. This was soon followed by partial overflowing of the waste. The analysis of the overflowing liquid indicated that it was sewage of the same composition

as the input from the septic tank.

On April 12, 1970, the feed rate was reduced to 24 $l/m^2$ (½ $gal/ft^2$) per day, which stopped overflowing of the waste. This also reduced the free ammonia content in the final effluent with corresponding increase in nitrate and lower BOD and suspended solids.

The values of the various parameters during the period of operation at 49 $l/m^2$ (1 $gal/ft^2$) per day are shown in Tables 10 and 11. It was observed that the BOD and suspended solids in the effluent for 85% of the time were equal to or less than 6.5 and 3.0 mg/l respectively.

The system operated satisfactorily at half rate for almost two months and would have continued for a longer period at this rate, perhaps without causing any problems. It was, however, shut down in order to replace the media by another sand similar to that which was going to be used in the Bed No. 1 but mixed with "red mud" for the treatment of phosphates in the waste. The Bed No. 4 was to act as a control for studying phosphate removal by Bed No. 1.

The bed was dug out on July 25, 1970. Since it had been shut down for 10 weeks, the filter sand had all dried up and nothing abnormal could be observed.

Modified Bed No. 4

$D_{10}$ = 0.24 mm $\qquad\qquad$ $C_u$ = 3.9

The bed was filled with sand of $D_{10}$ = 0.24 mm and $C_u$ = 3.9, the same sand as for Bed No. 1. The bed was started on July 29, 1970 at loading of 24 $l/m^2$ (½ $gal/ft^2$) per day. The feed rate was increased to 49 $l/m^2$ (1 $gal/ft^2$) per day on September 17, 1970.

During operation of the system it had been observed that the outflow of the treated effluent was relatively less than the inflow. The checking of the calibration of the tipping bucket feed into Beds Nos. 1 and 4 indicated no error. There was no indication of any build-up of the waste in the bed nor were there any signs of ponding. Moreover, the dissolved oxygen in the effluent had been 5.0 to 8.0 mg/l, showing that the system was operating aerobically. About 12 gallons (545 litres) of water was poured on different days over two different areas of the bed. In one case, most of it was received at the effluent outlet whereas in the other case no effluent appeared. The cause of this difference could be attributed to some break in the plastic lining of the box through which the effluent could be discharging from the bottom of the bed, underground.

In March 1971 the loading rate was increased to 73 $l/m^2$ (1½ $gal/ft^2$) per day as was done simultaneously for Bed No. 1. The outcoming final effluent remained lesser than input. During a dye test mud turned green under the effluent receiving bucket confirming that there was a leak in the bed.

The system was put on a six-hourly timed loading effective from November 18, 1971. It operated at a 1½ $gal/ft^2$ per day rate during this period.

The values for the various parameters during the three periods are given in Tables 10 and 11.

The BOD for the three periods in 85% of the samples was equal to or less than 7.4, 8.5 and 2.1 mg/l respectively.

The corresponding values for the suspended solids were 1.6, 6.5 and 9.5 mg/l. The values for total phosphorus were up to 11.9, 5.1 and 6.4 mg/l P during the three periods.

The values for various parameters considering the entire period of operation under report are given in Table 34.

6.6 Filter Bed No. 5

$D_{10}$ = 1.0 mm $C_u$ = 2.1

Filter Bed No. 5 was commissioned on October 6, 1969 with sewage loading of 49 $l/m^2$ (1 $gal/ft^2$) per day. The BOD value in the sample of the effluent on the following day was 85.0 mg/l. It continued decreasing in successive samples. The values on the 3rd, 5th and 10th day were 28, 13 and 8 mg/l respectively. After two weeks operation it had come down to 5 mg/l. The suspended solids in corresponding period after fluctuating between 8 and 65 mg/l were reduced to 2.5 mg/l. The nitrate concentration also increased but the corresponding free ammonia remained high, usually above 4 mg/l. From February 1970, however, free ammonia started decreasing to values often less than 1 mg/l and sometimes not detected at all during the first period of operation when BOD and suspended solids for 85% of the time were equal to or less than 6.2 and 4.2 mg/l respectively.

In July 1970, the top soil covering the filter was removed and the level of the distributor pipes was checked. The bed was again covered with the top soil.

The loading rate of sewage input was increased to 73 $l/m^2$ (1½ $gal/ft^2$) per day, on March 5, 1971. On October 25, 1971 the loading pattern was changed to six-hourly automatic time feed.

The values of the various indicators are shown in Tables 12 and 13 and those considered to be overall for the entire period in Table 35.

The BOD for the four periods, 85% of the time, was equal to or less than 6.2, 4.3, 5.9 and 6.2 mg/l respectively. There was no significant change in BOD values with the increase of loading rate from 49 $l/m^2$ to 73 $l/m^2$ ( 1 to 1½ $gal/ft^2$) per day or by trickle flow and six hourly controlled feed. The suspended solids for the corresponding periods were up to 4.2, 1.7, 1.8 and 10 mg/l.

The value of free ammonia which was up to 13 mg/l N in 85% of samples during the first period was reduced to 5.6 mg/l N in the second period and to 1 and 1.4 mg/l N in the third and the fourth period respectively.

On the basis of the entire period of operation of the system from September 1969 to March 1973 the values of BOD and suspended solids in 85% of the samples were equal to or less than 6.9 and 6.5 mg/l respectively.

6.7 Filter Bed No.6

$D_{10}$ = 2.5 mm $\qquad\qquad$ $C_u$ = 1.2

Bed No. 6 was put into operation at 49 $l/m^2$ (1 $gal/ft^2$) per day on October 6, 1969, but had to be shut down on the following day to repair a leak in the collector pipe. It was restarted on October 15, 1969. After 48 hours operation, the BOD value in the final effluent was 6.6 mg/l and suspended solids 9.2 mg/l.

There was little oxidation of nitrogen compounds, the values for nitrate being less than 1 mg/l N up to the

middle of November 1969. The free ammonia during the period had been generally between 24 and 36 mg/l N.

In July 1970 the level of the distributor pipes was checked for this bed as for bed No. 5.

During Period II there appeared to be a considerable reduction in free ammonia. The values for 50% and 85% of the time were equal to or less than 4.9 and 8.8 mg/l respectively. In Period I the corresponding values were 8.8 and 27.0 mg/l N.

The loading rate was increased to 73 $l/m^2$ ($1\frac{1}{2}$ $gal/ft^2$) on March 5, 1971 and an automatic 6 hourly programmed feeding on November 18, 1971, at the same rate. The system continued operating without any problem.

The analyses for the various indicators for the four periods are given in Tables 14 and 15 and for the entire period in Table 36.

The values for BOD in 85% of the samples for the four periods were equal to or less than 10, 8.0, 13.0 and 17.5 mg/l, The corresponding values for suspended solids were 10.5, 7.6, 9.1 and 28 mg/l.

It could be observed that with the rate of $1\frac{1}{2}$ $gal/ft^2$ per day loading six-hourly produced an effluent with relatively much higher BOD and suspended solids, 19.5 and 28 mg/l respectively as compared to the effluent with the same rate but loading as trickle flow input during period No. III when BOD and suspended solids were equal to or less than 13.0 and 9.1 mg/l respectively.

## 7.0 DISCUSSION

From the laboratory analyses of the samples collected daily for a few days at the start of the studies it was observed that the oxidation of nitrogen compounds of the waste into nitrates in the filter beds started at a much later date and took a relatively longer time for the stabilization of the processes as compared to other compounds as indicated by BOD and suspended solids. The difference was more apparent in beds Nos. 5 and 6. The reduction in BOD or COD and suspended solid values was effected within 2 to 5 days. Although the nitrate content started increasing the free ammonia concentration remained high. It was not until after six months of operation that it dropped to 1 mg/l.

Filter beds 1 and 4 provided satisfactory treatment for only 4 months at the loading rate of 49 $l/m^2$ (1 $gal/ft^2$) per day after which overflowing due to partial surface clogging of media occurred. Then the two beds were refilled with a sand of effective size 0.24 mm and uniformity coefficient of 3.9. Bed No. 1 contained an 8 inch layer of the sand mixed with red mud. Filter beds 2, 3,5 and 6 have been in operation continuously without alterations since September 1969.

For comparing the changes in performance, the statistical analysis of the laboratory results for the four periods are shown together for each parameter Tables 18 to 30.

During the season when the water table was high, the groundwater had been infiltrating into the sewage collection system. The problem was more acute during period IV as indicated by the much lower values of the various parameters in the analysis of the septic tank effluent.

7.1 BOD and COD - Tables 18 and 19

The BOD values for 50% of the samples of the effluent from the six beds during each of the four Periods I to IV, while operating under different conditions of sewage input i.e. loading at 49 $l/m^2$ (1 $gal/ft^2$) per day, 73 $l/m^2$ (1½ $gal/ft^2$) per day, as trickle flow or as on six hourly periodic feeding, were equal to or less than 5.4 mg/l. The BOD values in the septic tank effluent corresponding to the four periods were 86, 135, 110 and 55 mg/l.

In 85% of the samples during Period I when all the beds were receiving sewage at the rate of 49 $l/m^2$ ( 1 $gal/ft^2$) per day the values for BOD were equal to or less than 10.0 mg/l. The lowest value of 6.2 mg/l was for bed No. 5 and the highest of 10.0 mg/l for bed No. 6.

For Period II when the loading rate on beds Nos. 2 and 3 had been increased from 49 $l/m^2$ to 73 $l/m^2$ (1 gal to 1½ $gal/ft^2$) per day, bed No. 2 showed an increase in BOD from 7.0 to 9.5 mg/l whereas a decrease from 8.6 to 8.1 mg/l for bed No. 3 was recorded. With the continuous operation of beds No. 5 and 6 at 49 $l/m^2$ (1 $gal/ft^2$) per day for 1½ years there appeared to be some improvement in the values of BOD and the values changed from 6.2 to 4.3 mg/l and 10.0 to 8.0 mg/l respectively.

During Period III, beds Nos. 1, 4, 5 and 6 were operated at 73 $l/m^2$ (1½ $gal/ft^2$) per day in addition to bed No. 2 and bed No. 3 already in operation at that rate. There was no significant change in the BOD of the effluents from bed No. 2 and bed No. 3 with the continued operation at the same rate. In case of beds Nos. 1, 4 and 5 however, which had

previously operated at 49 $l/m^2$ (1 $gal/ft^2$) per day an increase in BOD from 5.5 to 8.4 mg/l, 7.4 to 8.5 mg/l and 4.3 to 5.9 mg/l respectively was observed. A significant increase in BOD from 8.0 to 13.0 mg/l was only in case of bed No.6 which contained sand with effective size of 2.5 mm. The percent of reduction of BOD for bed No.6 was 94.3% as compared to 97.4% in Period II.

On changing the pattern of sewage loading of the filters in Period IV from trickle feed to six-hourly but maintaining the rate of sewage at 73 $l/m^2$ (1½ $gal/ft^2$) per day as in Period III there appeared to be a lowering of BOD in the effluents from Beds Nos. 1, 2, 3 and 4. The decrease in values could have been due to the low BOD of 159 mg/l of the incoming septic tank effluent as compared to 230 mg/l in Period III. In case of filter bed No. 5 and No. 6, BOD increased from 5.9 to 6.5 mg/l and 13.0 to 17.5 mg/l respectively.

Any advantage of providing longer resting periods in between 6 hourly sewage loading into the beds was not established. Apparently, the efficiency of treatment of filter bed Nos. 5 and 6 for BOD was reduced from 97.4% to 95.9% and from 94.3% to 88.9% respectively. The most adverse effect was on bed No. 6. The other filter beds showed an improved efficiency by 0.3 to 2.4%.

The values of COD as expected followed in general a similar trend as BOD. In 85% of the samples during Period III and IV these were in the range of 37 to 53 mg/l and 23 to 74 mg/l respectively. The relatively high values for COD were for bed No.6. The COD in septic tank effluent for the corresponding periods was 335 and 327 mg/l.

7.2 Suspended Solids - Table 20

In 50% of the samples of septic tank effluent in Periods I to IV the suspended solids were 72, 65, 64 and 43.8 mg/l or less respectively. In corresponding 50% of samples of the effluent from the filter beds, suspended solids were equal to or less than 5.2 mg/l quite often less than 1 mg/l excepting during Period IV in bed No. 6 when the suspended solids were 9.4 mg/l.

There appeared to be a tendency for an increase in effluent suspended solids with the change in the pattern of loading of sewage from trickle feed to six hourly feed.

During Periods I and II the highest suspended solids were 10.5 mg/l from bed No. 6 and the lowest of 1.5 mg/l in bed No. 1. Excepting for bed No. 6 the values were generally less than 5.0 mg/l with the increase in loading rate from 49 $l/m^2$ to 73 $l/m^2$ (1 gal to 1½ $gal/ft^2$) per day in Period II for beds Nos. 2 and 3. Unlike BOD there was a slight decrease in suspended solids. The values were reduced from 5.0 and 3.5 mg/l to 3.5 and 2.4 mg/l respectively, but again increased to 7.0 and 2.9 mg/l in Period III while operating at the same rate.

There was little effect of increased loading rate on bed Nos. 1 and 5 but suspended solids increased from 1.6 and 7.6 mg/l to 6.5 and 9.1 mg/l in bed Nos. 4 and 6 respectively.

During Period IV when the loading of the sewage was six-hourly, there was an increase in concentration of suspended solids in effluent from all the beds. Filter beds Nos. 5 and 6 had an increase from 1.8 and 9.1 mg/l to 12.0 and 28.0 mg/l with a change in efficiency of removal from 98.7% and 93.6%

to 88.5% and 73.0% respectively. In the other beds the reduction in efficiency was in the range of 3 to 5%. Beds Nos. 2, 3 and 4 had an efficiency of 92% and bed No. 1 had 94.2%.

7.3 Volatile Suspended Solids - Table 21

Volatile suspended solids were determined during Period II and III. In 50% of the samples during Period II the values were always less than 1.0 mg/l for all the beds excepting bed No. 6 which had equal to or less than 1.1 mg/l. For Period III volatile suspended solids were always less than 2.0 and 2.7 mg/l for bed Nos. 4 and 6 respectively.

In 85% of the samples in Period II the values of volatile suspended solids were always less than 1.0 mg/l for beds Nos. 1, 2, 4 and 5 but were up to 1.5 and 4.3 mg/l for beds No. 3 and 6 respectively. In Period III the volatile suspended solids were relatively higher and were in the range of 1.4 to 5.2 mg/l. Bed No. 6 had the highest value of 5.2 mg/l.

7.4 Nitrogen (Free Ammonia, Organic, Nitrite and Nitrate) Tables 22, 23, 24 and 25.

The starting and progress of nitrification process varied in the filter beds from one to six weeks. There appeared to be no correlation of this process with the grain size of the filter media. Filter bed No. 6 took over five weeks before effluent nitrate content started increasing from less than 1.0 mg/l. The free ammonia content had remained high in beds 1, 2, 4 and 6 during the first five months of operation.

Filter bed No. 2 showed considerable decrease in ammonia from the middle of March 1970, whereas filter beds Nos. 1 and 4 showed little change till the beds failed. Filter bed No. 6 continued showing high free ammonia content during Period I.

There was a significant improvement in stabilization of nitrogen compounds with the time of operation of the systems. The free ammonia in beds Nos. 2, 5 and 6 which in 85% of the samples during Period I was equal to or less than 15, 13 and 27 mg/l N was reduced to 9.4, 5.6 and 8.8 mg/l N during Period II. There was further decrease in ammonia as indicated in Period IV when the corresponding values were 0.8, 1.4 and 3.2 mg/l.

The septic tank effluent in 85% of the samples during the four periods had free ammonia equal to or less than 40, 37, 15.5 and 27 mg/l N. The efficiency of ammonia removal during the last period was 95% to 99% for bed Nos. 1 to 5. For bed No. 6 it was 88.2%.

The presence of free ammonia and nitrite indicated that the oxidation of nitrogen compounds was not complete.

The nitrate content in all the beds was in the range of 26.0 to 28.8 mg/l N during the last period. The values were relatively lower than in the previous periods apparently due to weaker septic tank effluent for loading the beds during this period.

7.5 Phosphorus - Table 26

The concentration of phosphorus in the six beds during Period I, after which the filter media in bed Nos. 1 and 4 had been replaced, for 85% of the samples was in the range of 15.3

to 18.6 mg/l. The corresponding value for septic tank effluent was 22.2 mg/l P. This represented an efficiency of removal of phosphorus to be 13.7 to 30.5%.

The new filter bed No. 1 which contained "red mud" as an additive and had been put into operation at the beginning of Period II produced an effluent containing phosphate of 2.4, 2.7 and 3.3 mg/l P during the three periods of operation. This showed a phosphorus removal efficiency of 88.9, 79.4% and 72.5% respectively when compared to the corresponding septic tank effluent. In the case of filter beds Nos. 2, 3, 5 and 6 the phosphorus removal was in the range of 26.3% to 36.2% when averaged over the entire period. For bed No. 4, however, (control for bed No. 1) the efficiency was approximately 51%.

There did not appear to be any direct correlation between the physical characteristics of the filter media used and the phosphate removal during the entire period of operation of the system. Apparently filter beds containing chemically active ingredients in sands were capable of removing relatively more phosphate. The filter bed No. 1 containing red mud reduced phosphorus considerably and is likely to continue removing phosphorus at a much higher efficiency as compared to the beds containing chemically inactive filter media. However, there has been an indication of drop in the efficiency of removal of phosphate during the three years continuous operation of the system from 88.9% to 72.5%.

7.6 MBAS - Table 27

The septic tank effluent had Methylene Blue Active substances (MBAS) values for 85% of the samples in the range of

5.0 to 11.8 mg/l during the four periods. There was a considerable reduction during treatment in the filter beds and the concentration of MBAS in the effluents was 0.66 to 0.92 mg/l or less when considered in 85% of the sample. In 50% of the samples however, these were 0.40 to 0.51 mg/l when the septic tank effluent had an average of 5.1 mg/l MBAS. Again no correlation could be observed between the filter media and the MBAS reduction.

7.7 Total Solids - Table 28

The values for total solids for 50% of the samples for all the beds during Period I were in the range of 660 to 740 mg/l. In 85% of the samples the values were 800 to 880 mg/l. The corresponding total solids in the septic tank effluent were 660 and 790 mg/l. There was a relative increase of solids in effluents from all the beds excepting from bed No.6 which had almost the same values as were in the septic tank effluent. During Period IV after about 3½ years operation of the system the total solids in 50% of the samples were between 752 and 808 mg/l and in 85% of the samples between 915 and 1028 mg/l. The septic tank effluent had corresponding values of 747 and 939 mg/l. Increase in total solids in the filter effluents could be due to the oxidation of the compounds present in the septic tank effluent discharging into the filter beds.

7.8 Coliforms - Tables 29 and 30

There was considerable reduction in the total and fecal coliforms in the effluent from the beds as compared to that from septic tank. The counts however, were still very high. In 85% of the samples over the entire period of operation, the

total coliform counts were between 218,000 and 9,923,000 and the fecal coliforms were, 156,000 to 984,000 per 100 ml. Corresponding numbers in septic tank effluent were 31,694,000 and 3,836,000 per 100 ml. Although no exact correlation between the grain size and the coliforms removal could be established for filter beds with $D_{10}$ = 0.15 to 0.6 mm, there appeared to be an increase in the counts with the grain size higher than 0.6 mm. Filter bed No. 5 ($D_{10}$ = 1.0 mm) had total and fecal coliform 3,352,000 and 249,000 per 100 ml. respectively. Filter bed No. 6 with $D_{10}$ = 2.5 mm had the corresponding counts of 9,923,000 and 984,000 per 100 ml.

7.9 Water Usage - Table 3

The water used by each family in the seven residences was found to vary over a wide range. The average for 3½ years period ranged between 119 l (26.2 gal) and 207 l (45.6 gal) per person per day. On the basis of the community as a whole (24 - 32 persons) the average water usage was 168 l (37 gal) per person per day.

## 8.0 RED MUD AND PHOSPHORUS REMOVAL

In filter bed No. 1 treatment for phosphate was affected by the filter sand and by the presence of red mud containing compounds of calcium, aluminium and iron. The filter sand used in this and in the control filter bed No.4 apparently was capable of removing relatively more phosphates than the filter media used in the other beds.

Phosphorus concentration in the effluent from filter bed No. 1 in 85% of the samples over the entire period of operation of the system i.e. from August 1970 to March 1973, was equal to or less than 2.7 mg/l P. The corresponding values for filter bed No. 4 and for the septic tank effluents were 8.0 mg/l P and 16.7 mg/l P respectively.

The efficiency of removal of phosphorus in the control filter bed No. 4 by sand only was 52.1% whereas in filter bed No. 1 by the sand and the red mud combined was 83.8%. During the initial nine months of operation of bed No. 1 the efficiency was estimated to be 89.9% whereas in the last period ending in March 1973 it was 79.4%.

The total amount of septic tank effluent discharged into each of the two beds from July 1970 to March 1973 as observed from records was $0.622 \times 10^6$ litres.

On the basis of chemical analyses of the filter bed input and output streams for the two beds the quantity of phosphorus calculated was as follows:

| | | |
|---|---|---|
| Amount of P in S.T. effluent | = 4,720 gm | (1) |
| Amount of P in control filter bed effluent | = 2,980 gm | (2) |
| Amount of P in Red Mud filter effluent | = 995 gm | (3) |
| Phosphorus removed by sand only (1-2) | = 1,740 gm | |
| Phosphorus removed by sand and Red Mud (1-3) | = 3,729 gm | |
| Phosphorus removed by Red Mud only (2-3) | = 1,689 gm | |
| | = 1.689 Kgm | |

From the chemical analysis of red mud (Appendix I) the theoretical amount of this material required for phosphorus removal is in the ratio of 4:1. Consequently in order to remove 1.69 Kgm of phosphorus, the red mud required would be 6.76 Kgm.

The weight of red mud mixed as 4% in the 20 cm (8 in) deep layer 3.7 m x 3.0 m (12 ft x 10 ft) sand was 145 Kgm (320 lbs). This amount on stoichiometric basis is expected to react with phosphates for removing 36.2 Kgm of P. Out of this, only 6.76 Kgm or 18.6% is assumed to have reacted with the waste. This leads to the conclusion that the system should continue to operate effectively for a long time. In practice it has been observed, as stated earlier, that there is a tendency towards a steady drop in the efficiency of removal of the phosphates during 2½ years operation. Apparently the removal of phosphates is dependent, besides some other factors, on the degree of surface adsorption (10,11) and the solubility of the compounds involved in the chemical reactions.

Continued operation of the system might be able to indicate the useful life of the additives as mixed with sand in the filter bed. The values of phosphorus in the effluents from the septic tank, filter bed Nos. 1 and 4 have been plotted against time and the amount of sewage treated in Figure 8, (Appendix III).

## 9.0 CONCLUSIONS

1. Filter beds containing "asphalt" sand ($D_{10}$ = 0.15 mm) and "concrete" sand ($D_{10}$ = 0.19 mm) had a limited useful life if loaded at 49 l/m$^2$ (1 gal/ft$^2$) per day. These would have operated satisfactorily for a much longer period if loaded at a lower rate. There were indications of clogging of the media at the infiltration surface after four months operation. During that period the effluents from the two beds (asphalt sand and concrete sand) had BOD equal to or less than 7.0 mg/l and 6.5 mg/l respectively in 85% of the samples. The corresponding values for suspended solids were 5.0 mg/l and 3.0 mg/l. There was, however, relatively high free ammonia, up to 21 mg/l N, in the effluents indicating that stabilization of nitrogeneous compounds was not completed.

2. The operation of the filter beds, effective size of media in the range of 0.24 mm to 2.5 mm and uniformity coefficient of 1.2 to 3.9, for a period of 30 to 42 months, has indicated that the filters were providing satisfactory treatment. The bed when loaded with septic tank effluent as gravity flow at 49 l/m$^2$ (1 gal/ft$^2$) per day produced an effluent with a BOD of 6.1 mg/l and 10.0 mg/l or less for 50% and 85% of the time respectively. The corresponding values for suspended solids were 3.1 mg/l and 10.5 mg/l.

3. On increasing the sewage loading rate to 73 $l/m^2$ (1½ $gal/ft^2$) per day as gravity flow only filter bed containing pea gravel, effective size 2.5 mm showed an increase in BOD when the values in 85% of the samples were equal to or less than 13.0 mg/l as compared to 10.0 mg/l in Period II. For the other filter beds corresponding values for BOD were in the range of 5.9 mg/l to 9.4 mg/l. The suspended solids from all the beds were in the range of 1.5 mg/l to 9.1 mg/l.

4. When the feed pattern was changed to once every six hours there was

   (a) no significant change in the efficiency of treatment for BOD in all except the bed containing pea gravel ($D_{10}$ = 2.5 mm) for which the value increased from 13.0 mg/l to 17.5 mg/l.

   (b) an increase in effluent suspended solids from all the beds. The values in general were up to 10.0 mg/l. These were significantly higher, 28.0 mg/l for pea gravel ($D_{10}$ = 2.5 mm).

5. The nitrification process was slow at first but during six months operation there was a gradual improvement with time in the stabilization of nitrogeneous compounds.

6. The effluents from all the systems contained fecal coliforms; relatively more in the effluent from the filter bed containing gravel $D_{10}$ = 2.5 mm. There was, however, a considerable reduction in all cases when compared to septic tank effluent.

7. The efficiency of phosphorus removal by the filter media without chemical additive on the average was in the range of 26.3 to 36.2%, excepting for medium sand which showed 51.1% during one of the periods.

   The filter bed containing red mud had an efficiency of phosphorus removal of 88.9%, 79.4% and 72.5% for the three periods for 85% of the samples. A steady decrease in the efficiency was apparent but from the rate of decrease, the life of the system could be expected to be another 2 to 3 years before arriving at a level of 50% removal of phosphorus.

## 10.0 SUMMARY

Underdrained filters, as an alternative to conventional tile fields, are considered effective in treating septic tank effluent. This conclusion is the result of a study initiated in 1969 regarding treatment of the effluent by sands of different physical characteristics, i.e. effective size and uniformity coefficient.

The commonly available sands from gravel pits used as filter media were in the range of 0.15 mm to 2.50 mm effective size and 1.0 to 4.5 uniformity coefficient. The filters were loaded with the septic tank effluent at 49 $l/m^2$ (1 $gal/ft^2$) per day and 73 $l/m^2$ (1½ $gal/ft^2$) per day as trickle feed and at controlled frequency of four times a day as a siphon discharge.

The filter beds, when loaded on the trickle septic tank discharge pattern, produced effluents with Biological Oxygen Demand ($BOD_5$) and Suspended Solids (S.S.) in 85% of the samples equal to or less than 7.8 mg/l and 4.6 mg/l respectively. The corresponding values for septic tank effluent being 237 mg/l and 139 mg/l, the efficiency of treatment in each case was 96.5%. The filters containing sands, effective size 0.15 mm and 0.19 mm had a limited useful life when loaded at 49 $l/m^2$ (1 $gal/ft^2$) per day.

When the feed pattern was changed to once every six hours there appeared to be no significant change in the efficiency for BOD treatment in all the beds excepting bed containing pea gravel ($D_{10}$ = 2.5 mm) where it declined to 89%. There was, however, a significant decrease in the efficiency of suspended solids removal, which varied from 85% to 93% for different filter beds, the lowest efficiency of 85% was for pea gravel.

The phosphorus removal by the filter media without chemical additives, on the average, was in the range of 26.3% to 36.2%. The filter bed containing "red mud", a waste by-product of Bauxite purification containing oxides of calcium, aluminum and iron, however, showed an efficiency of 88.9%, 79.4% and 72.5% during the 1st. 2nd. and 3rd. years of operation respectively.

The stabilization of nitrogeneous compounds was a relatively slow process and it took more than six months for some of the filter beds before satisfactory reduction in free ammonia was observed.

Effluents from all the beds contained fecal coliforms, relatively greater in number ($1.7 \times 10^6$ /100 ml) from the filter sand of effective size 2.5 mm.

The average water usage in the seven residences was in the range of 119 litres to 207 litres (26.2 gal to 45.6 gal) per person per day.

# TABLE 1

All analyses
mg/litre unless otherwise indicated

## LABORATORY ANALYSES OF EFFLUENTS*

**Municipality:** **Report to:**

**Source:** Whitby Project

**Date Sampled:** Aug.2, 1972 **by:**

| Effluent | 5-Day B.O.D. | Susp. Solids | COD | MBAS | NITROGEN AS N – | | | | PHOSPHORUS AS P | | Total Solids | Coliforms $10^3$/100 ml | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Free Ammonia | Total Kjeldahl | Nitrite | Nitrate | Tot. | Sol. | | Total | Fecal |
| Septic Tank | 160 | 70 | 300 | 9.4 | 37. | 45 | .03 | .16 | 10. | 9.1 | 670 | 33,000 | 2,200 |
| Filter bed: | | | | | | | | | | | | | |
| 1 | 1.8 | 5 | <30 | 0.5 | 0.2 | 1.5 | .01 | 25. | 1.5 | 1.4 | 880 | 69 | 17 |
| 2 | 0.6 | 0 | <30 | 0.1 | 0.2 | 1.0 | .01 | 22. | 3.8 | 3.7 | 770 | 200 | 25 |
| 3 | 0.8 | 0 | <30 | 0.2 | 0.1 | 1.0 | .04 | 37. | 5.5 | 5.4 | 800 | 2300 | 420 |
| 4 | 0.8 | 5 | <30 | 0.2 | 0.1 | 1.0 | .06 | 30. | 6.0 | 5.3 | 890 | 140 | 61 |
| 5 | 4.0 | 5 | <30 | 0.4 | 0.4 | 1.5 | .03 | 28. | 7.5 | 6.8 | 770 | 720 | 270 |
| 6 | 6.0 | 5 | 30 | 0.3 | 2.0 | 4.0 | .22 | 24. | 8.0 | 7.1 | 700 | 7300 | 390 |

* Similar laboratory analyses are on file for the period – September 1969 to March 1973.

12-064

## TABLE 2

All analyses
mg/litre unless otherwise indicated

## LABORATORY ANALYSIS OF RAW SEWAGE *

**Municipality:** **Report to:**

**Source:**

**Date Sampled:** September 28 - 30 1969.

| 1969 | 5-Day B.O.D. | Susp. Solids | COD | MBAS | NITROGEN AS N - | | | | PHOSPHORUS AS P | | Total Solids | Coliforms $10^5$/100 ml | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Free Ammonia | Organic | Nitrite | Nitrate | Tot. | Sol. | | Total | Fecal |
| Sept.28 | - | 583 | 794 | 4.5 | 41.6 | 8.7 | 0.11 | < 1.0 | 17.6 | - | 999 | + 8.0 | + 0.8 |
| " 29 | 735 | 1860 | 3792 | 5.2 | 52.2 | 10.5 | < 0.001 | < 1.0 | 25.1 | - | 2064 | - | - |
| " 30 | 740 | 1720 | 3264 | 6.7 | 53.3 | 12.4 | < 0.001 | < 1.0 | 37.5 | - | 2972 | - | - |

* Composite of grab samples collected from M.H.5 (Fig. 1) every 15 minutes between 0700 hrs. and 0830 hrs.

TABLE NO. 3

WATER USAGE

gal/person/day

| Residence | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Period I | 41.9 | 19.8 | 31.6 | 32.4 | 28.4 | 28.4 | 38.3 |
| Period II | 40.1 | 24.5 | 33.8 | 40.3 | 37.5 | 41.0 | 34.9 |
| Period III | 53.1 | 27.2 | 37.7 | 39.6 | 39.8 | 46.6 | 56.5 |
| Period IV | 47.3 | 33.3 | 25.6 | 36.0 | 47.5 | 30.8 | - |
| Average (gallons) | 45.6 | 26.2 | 32.2 | 37.1 | 38.3 | 36.7 | 43.2 |
| (litres) | 207 | 119 | 146 | 168 | 174 | 167 | 196 |

Community Average = 168 l (37 gal) per person per day.

* Period I Sept. 28, 1969 to July 23, 1970

Period II July 27, 1970 to March 2, 1971

Period III March 3, 1971 to November 17, 1971

Period IV November 18, 1971 to March 12, 1973.

Filter Bed No.1

$D_{10}$= 0.19 mm; $C_u$= 4.4 (Period I only)

$D_{10}$= 0.24 mm; $C_u$= 3.9 (Period II-IV)

TABLE NO. 4

Statistical Analysis Effluent Quality

| *Period | Daily Loading Rate | Samples | ** Values Equal to or less than $BOD_5$ | Suspended Solids | Volatile Sus-solids | Total Solids | COD | MBAS | Total Phos. P |
|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | |
| | 49 $l/m^2$ (1 gal/$ft^2$) | 15% | 3.0 | 1.0 | - | 620 | 26 | 0.45 | 3.26 |
| | | 50% | 4.6 | 1.8 | - | 700 | 38 | 0.94 | 7.82 |
| | | 85% | 7.0 | 5.0 | - | 800 | 54 | 2.00 | 18.25 |
| | | | Filter Media Changed | | | | | | |
| II | | | | | | | | | |
| | 49 $l/m^2$ (1 gal/$ft^2$) | 15% | 0.5 | <1.0 | <1.0 | 640 | 19 | 0.28 | 1.17 |
| | | 50% | 1.7 | <1.0 | <1.0 | 700 | 27 | 0.47 | 1.63 |
| | | 85% | 5.5 | 1.5 | <1.0 | 780 | 39 | 0.79 | 2.38 |
| III | | | | | | | | | |
| | 73 $l/m^2$ (1.5 gal/$ft^2$) | 15% | 0.7 | <1.0 | <1.0 | 680 | 17 | 0.29 | 1.76 |
| | | 50% | 2.7 | <1.0 | <1.0 | 750 | 25 | 0.43 | 1.76 |
| | | 85% | 8.4 | 1.5 | 1.4 | 820 | 37 | 0.62 | 2.74 |
| IV | | | | | | | | | |
| | 73 $l/m^2$ (1.5 gal/$ft^2$) | 15% | 0.6 | 0.4 | - | 682 | - | 0.16 | 0.86 |
| | | 50% | 1.5 | 1.6 | - | 808 | - | 0.29 | 1.70 |
| | | 85% | 3.9 | 6.0 | - | 956 | - | 0.86 | 3.35 |

* Period I Sept. 28, 1969 to July 23, 1970 Period III March 3, 1971 to Nov. 17, 1971

Period II Sept.17 1970 to March 2, 1971 Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l.

Filter Bed No. 1

$D_{10}$= 0.19 mm; $C_u$= 4.4 (Period I only)
$D_{10}$= 0.24 mm; $C_u$= 3.9 (Period II -IV)

TABLE NO. 5

Statistical Analysis Effluent Quality

| *Period | Daily Loading Rate | Samples | **Values Equal to or Less than Free Ammonia N. | Organic N | Nitrite N | Nitrate N | Total Coliform | Fecal |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| | | 15% | 9.8 | 0.56 | 0.12 | 0.10 | 8.5 | 0.17 |
| | 49 $l/m^2$ (1 $gal/ft^2$) | 50% | 13.0 | 0.80 | 0.43 | 10.0 | 53 | 5.0 |
| | | 85% | 17.0 | 1.15 | 1.50 | 50.0 | 340 | 140 |
| II | | | Filter Media Changed | | | | | |
| | | 15% | N.D. | 0.23 | 0.02 | 20.0 | 0.06 | 0.03 |
| | 49 $l/m^2$ (1 $gal/ft^2$) | 50% | 0.06 | 0.38 | 0.17 | 32.0 | 0.71 | 0.29 |
| | | 85% | 1.70 | 0.62 | 1.00 | 52.0 | 8.0 | 4.2 |
| III | | | | | | | | |
| | | 15% | N.D. | 0.28 | - | 16.5 | 0.14 | 0.01 |
| | 73 $l/m^2$ (1.5 $gal/ft^2$) | 50% | 0.06 | 0.38 | 0.05 | 25.0 | 34.0 | 3.20 |
| | | 85% | 1.50 | 0.50 | 0.53 | 38.0 | 840 | 90.0 |
| IV | | | | | | | | |
| | | 15% | 0.02 | 0.31 | 0.02 | 11.4 | 0.38 | 0.25 |
| | | 50% | 0.06 | 0.64 | 0.02 | 18.1 | 4.7 | 0.66 |
| | 73 $l/m^2$ (1.5 $gal/ft^2$) | 85% | 0.25 | 1.25 | 0.02 | 28.8 | 59.2 | 1.8 |

* Period I Sept. 28, 1969 to July 23, 1970
Period II Sept.17, 1970 to March 2, 1971
Period III March 3, 1971 to Nov. 17, 1971.
Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l except Coliforms in thousands/100 ml.

TABLE NO.6

Statistical Analysis Effluent Quality

Filter Bed No. 2 $D_{10}$ =0.30 mm $C_u$ = 4.1

| *Period | Daily Loading Rate | Samples | ** Values Equal to or less than BOD$_5$ | Suspended Solids | Volatile Sus-solids | Total Solids | COD | MBAS | Total Phos. P |
|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | |
| | 49 l/m$^2$ (1 gal/ft$^2$) | 15% | 1.2 | 1.0 | - | 630 | 21 | 0.20 | 5.87 |
| | | 50% | 2.9 | 1.0 | - | 730 | 33 | 0.54 | 9.78 |
| | | 85% | 7.0 | 3.1 | - | 880 | 53 | 1.50 | 16.30 |
| II | | | | | | | | | |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 15% | 3.8 | < 1.0 | < 1.0 | 600 | 20 | 0.33 | 8.15 |
| ( | | 50% | 6.1 | < 1.0 | < 1.0 | 740 | 32 | 0.64 | 10.67 |
| | | 85% | 9.5 | 3.5 | < 1.0 | 900 | 50 | 1.25 | 14.34 |
| III | | | | | | | | | |
| | 73 l/m$^2$ (1.5 gal/ft2) | 15% | 0.9 | < 1.0 | < 1.0 | 620 | 18 | 0.29 | 3.03 |
| | | 50% | 2.9 | < 1.0 | < 1.0 | 730 | 30 | 0.43 | 5.18 |
| | | 85% | 9.4 | 1.0 | 4.2 | 870 | 53 | 0.65 | 8.80 |
| IV | | | | | | | | | |
| | 73 l/m$^2$ (1 gal/ft$^2$) | 15% | 0.4 | 1.0 | - | 619 | 30 | 0.14 | 2.22 |
| | | 50% | 0.9 | 2.4 | - | 780 | 30 | 0.16 | 3.59 |
| | | 85% | 2.3 | 8.1 | - | 1028 | 33 | 0.19 | 5.82 |

* Period I Sept. 28, 1969 to July 23, 1970
Period II Oct. 26, 1970 to March 2, 1971
Period III March 3, 1971 to Nov. 17, 1971
Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l.

## TABLE NO. 7

Statistical Analysis Effluent Quality

Filter Bed No. 2
$D_{10}$ = 0.30 mm $C_u$ = 4.1

| *Period | Daily Loading Rate | Samples | **Values Equal to or Less than Free Ammonia N. | Organic N | Nitrite N | Nitrate N | Total Coliform | Fecal |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| | | 15% | 4.0 | 0.30 | 0.16 | 12 | 0.66 | 0.06 |
| | 49 l/m$^2$ (1 gal/ft$^2$) | 50% | 7.8 | 0.52 | 0.30 | 19 | 90 | 10.0 |
| | | 85% | 15.0 | 0.88 | 0.60 | 28 | 600 | 160 |
| II | | | | | | | | |
| | | 15% | 2.1 | 0.29 | 0.35 | 17 | 0.4 | 0.20 |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 50% | 4.5 | 0.48 | 0.52 | 26 | 10.0 | 3.5 |
| | | 85% | 9.0 | 0.70 | 0.66 | 39 | 110 | 6.0 |
| III | | | | | | | | |
| | | 15% | N.D. | 0.28 | 0.01 | 13 | o.10 | 0.05 |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 50% | 0.18 | 0.39 | 0.11 | 23.5 | 10.0 | 1.85 |
| | | 85% | 2.85 | 0.55 | 0.87 | 43 | 970 | 72.0 |
| IV | | | | | | | | |
| | | 15% | 0.03 | 0.27 | 0.02 | 7.2 | 0.62 | 0.36 |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 50% | 0.15 | 0.56 | 0.03 | 14.1 | 10.9 | 2.05 |
| | | 85% | 0.79 | 0.88 | 0.04 | 27.7 | 191 | 11.6 |

* Period I Sept. 28, 1969 to July 23, 1970 Period III March 3, 1971 to Nov. 17, 1971.
Period II Oct. 26,1970 to March 2, 1971 Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l except Coliforms in thousands/100 ml.

TABLE NO. 8

Statistical Analysis Effluent Quality

Filter Bed No. 3 $D_{10}$ =0,60 mm $C_u$ = 2.7

| *Period | Daily Loading Rate | Samples | ** Values Equal to or less than BOD$_5$ | Suspended Solids | Volatile Sus-solids | Total Solids | COD | MBAS | Total Phos. P |
|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | |
| | 49 l/m$^2$ (1 gal/ft$^2$) | 15% | 1.2 | 1.0 | - | 600 | 21 | 0.27 | 8.15 |
| | | 50% | 3.2 | 1.0 | - | 720 | 34 | 0.48 | 11.41 |
| | | 85% | 8.6 | 3.5 | - | 880 | 51 | 0.86 | 16.30 |
| II | | | | | | | | | |
| | 73 l/m$^2$ (1.5 gal/ft2) | 15% | 0.9 | <1.0 | <1.0 | 580 | 23 | 0.36 | 8.15 |
| | | 50% | 2.6 | 1.0 | <1.0 | 660 | 37 | 0.66 | 12.06 |
| | | 85% | 8.1 | 2.4 | <1.5 | 760 | 59 | 1.20 | 17.60 |
| III | | | | | | | | | |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 15% | 0.9 | <1.0 | <1.0 | 640 | 18 | 0.47 | 4.08 |
| | | 50% | 2.7 | <1.0 | <1.0 | 720 | 27 | 0.72 | 5.71 |
| | | 85% | 8.8 | 2.9 | 2.0 | 790 | 41 | 4.08 | 8.15 |
| IV | | | | | | | | | |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 15% | 0.6 | 0.8 | - | 595 | <30 | 0.09 | 2.59 |
| | | 50% | 1.5 | 2.6 | - | 660 | <30 | 0.16 | 4.21 |
| | | 85% | 3.5 | 8.2 | - | 732 | 30 | 0.31 | 6.82 |

* Period I Sept. 28, 1969 to July 23, 1970
Period II Oct. 26,1970 to March 2, 1971
Period III March 3, 1971 to Nov. 17, 1971
Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l.

TABLE NO.9

Statistical Analysis Effluent Quality

Filter Bed No. 3
$D_{10}$ = 0.60 mm $C_u$ = 2.7

| *Period | Daily Loading Rate | Samples | **Values Equal to or Less than Free Ammonia N. | Organic N | Nitrite N | Nitrate N | Total Coliform | Fecal |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| | 49 $l/m^2$ (1 gal/$ft^2$) | 15% | 0.1 | 0.17 | 0.19 | 19 | 0.52 | 0.18 |
| | | 50% | 3.1 | 0.35 | 0.60 | 27 | 35.0 | 4.40 |
| | | 85% | 8.0 | 0.76 | 1.90 | 40 | 2,000 | 100 |
| II | | | | | | | | |
| | 73 $l/m^2$ (1.5 gal/$ft^2$) | 15% | N.D. | 0.28 | 0.08 | 20 | 0.95 | 0.27 |
| | | 50% | 1.0 | 0.42 | 0.26 | 32 | 30.0 | 6.20 |
| | | 85% | 8.0 | 0.64 | 0.84 | 52 | 900 | 40.0 |
| III | | | | | | | | |
| | 73 $l/m^2$ (1.5 gal/$ft^2$) | 15% | N.D. | 0.28 | 0.01 | 19 | 0.67 | 0.07 |
| | | 50% | N.D. | 0.40 | 0.03 | 27 | 46 | 4.40 |
| | | 85% | 6.2 | 0.57 | 0.32 | 39 | 3100 | 270 |
| IV | | | | | | | | |
| | 73 $l/m^2$ 1.5 gal/$ft^2$) | 15% | 0.02 | 0.31 | 0.02 | 12 | 13.7 | 1.97 |
| | | 50% | 0.12 | 0.57 | 0.04 | 19 | 226 | 27.10 |
| | | 85% | 0.62 | 0.78 | 0.07 | 29 | 3724 | 372 |

* Period I Sept. 28, 1969 to July 23, 1970 Period III March 3, 1971 to Nov. 17, 1971.
Period II Oct.26, 1970 to March 2, 1971 Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l except Coliforms in thousands/100 ml.

Filter Bed No. 4

$D_{10}$= 0.15 mm $C_u$= 2.8 (PeriodI)

$D_{10}$= 0.24 mm $C_u$= 3.9 (Period II IV)

## TABLE NO.10

Statistical Analysis Effluent Quality

| *Period | Daily Loading Rate | Samples | ** Values Equal to or less than $BOD_5$ | Suspended Solids | Volatile Sus-solids | Total Solids | COD | MBAS | Total Phos. P |
|---|---|---|---|---|---|---|---|---|---|
| I | 49 $l/m_2$ (1 gal/$ft^2$ | 15% | 2.1 | 1.0 | - | 580 | 21 | 0.29 | 5.87 |
| | | 50% | 3.7 | 1.3 | - | 720 | 33 | 0.48 | 10.43 |
| | | 85% | 6.5 | 3.0 | - | 910 | 53 | 0.78 | 18.91 |
| II | | | Filter Media Changed | | | | | | |
| | 49 $l/m^2$ ( 1 gal/$ft^2$) | 15% | 0.3 | < 1.0 | < 1.0 | 650 | 14 | 0.30 | 7.01 |
| | | 50% | 1.4 | < 1.0 | < 1.0 | 730 | 22 | 0.45 | 9.13 |
| | | 85% | 7.4 | 1.6 | < 1.0 | 820 | 36 | 0.65 | 11.90 |
| III | | | | | | | | | |
| | 73 $l/m^2$ (1.5 gal/$ft^2$) | 15% | 2.0 | 1.5 | 1.0 | 690 | 11 | 0.27 | 4.24 |
| | | 50% | 4.1 | 3.1 | 2.0 | 770 | 26 | 0.39 | 4.56 |
| | | 85% | 8.5 | 6.5 | 3.9 | 850 | 35 | 0.55 | 5.05 |
| IV | | | | | | | | | |
| | 73 $l/m^2$ (1.5 gal/$ft^2$) | 15% | 0.6 | 0.6 | - | 685 | 2 | - | 2.65 |
| | | 50% | 1.1 | 2.4 | - | 819 | 7 | - | 4.10 |
| | | 85% | 2.0 | 9.5 | - | 979 | 24 | - | 6.45 |

* Period I Sept. 28, 1969 to July 23, 1970 Period III March 3, 1971 to Nov. 17, 1971

Period II Sept.17 1970 to March 2, 1971 Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l.

Filter Bed No. 4

$D_{10}$= 0.15 mm; $C_u$= 2.8 Period I only)

$D_{10}$= 0.24 mm; $C_u$= 3.9 (Period II -IV)

## TABLE NO. 11

Statistical Analysis Effluent Quality

| *Period | Daily Loading Rate | Samples | **Values Equal to or Less than Free Ammonia N. | Organic N | Nitrite N | Nitrate N | Total Coliform | Fecal |
|---|---|---|---|---|---|---|---|---|
| I | 49 l/m$^2$ ( 1 gal/ft$^2$) | 15% | 2.5 | 0.29 | 0.12 | 12 | 0.20 | 0.007 |
| | | 50% | 15.0 | 0.60 | 0.42 | 19 | 14.0 | 1.500 |
| | | 85% | 21.0 | 0.94 | 1.50 | 29 | 700 | 350 |
| | | | Filter Media Changed | | | | | |
| II | 49 l/m$^2$ (1 gal/ft$^2$) | 15% | N.D. | 0.17 | 0.01 | 29 | 0.04 | 0.004 |
| | | 50% | N.D. | 0.31 | 0.08 | 44 | 1.45 | 0.290 |
| | | 85% | 2.3 | 0.57 | 1.80 | 66 | 60.0 | 18.0 |
| III | 73 l/m$^2$ (1.5 gal/ft$^2$) | 15% | N.D. | 0.44 | 0.01 | 18 | 0.37 | 0.05 |
| | | 50% | 0.01 | 0.52 | 0.02 | 26 | 5.0 | 0.43 |
| | | 85% | 1.50 | 0.06 | 0.70 | 37 | 68 | 3.5 |
| IV | 73 l/m$^2$ (1.5 gal/ft$^2$) | 15% | 0.03 | 0.30 | 0.02 | 12 | 0.34 | 0.39 |
| | | 50% | 0.08 | 0.50 | 0.03 | 18 | 10.7 | 1.7. |
| | | 85% | 0.29 | 0.75 | 0.04 | 26 | 336 | 7.50 |

* Period I Sept. 28, 1969 to July 23, 1970 Period III March 3, 1971 to Nov. 17, 1971.

Period II Sept.17 1970 to March 2, 1971 Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l except Coliforms in thousands/100 ml.

TABLE NO. 12

Statistical Analysis Effluent Quality

Filter Bed No. 5 $D_{10}$ = 1.0 mm $C_u$ = 2.1

| *Period | Daily Loading Rate | Samples | ** Values Equal to or less than $BOD_5$ | Suspended Solids | Volatile Sus-solids | Total Solids | COD | MBAS | Total Phos. P |
|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | |
| | 49 l/m$^2$ (1 gal/ft$^2$) | 15% | 1.2 | 1/0 | - | 620 | 22 | 0.24 | 6.52 |
| | | 50% | 2.8 | 1.6 | - | 715 | 33 | 0.50 | 9.78 |
| | | 85% | 6.2 | 4.2 | - | 880 | 48 | 1.00 | 15.32 |
| II | | | | | | | | | |
| | 49 l/m$^2$ (1 gal/ft$^2$) | 15% | 0.6 | <1.0 | <1.0 | 620 | 16 | 0.30 | 8.31 |
| | | 50% | 1.6 | <1.0 | <1.0 | 720 | 26 | 0.50 | 11.73 |
| | | 85% | 4.3 | 1.7 | <1.0 | 840 | 43 | 0.84 | 17.28 |
| III | | | | | | | | | |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 15% | 0.6 | <1.0 | <1.0 | 665 | 12 | 0.30 | 4.73 |
| | | 50% | 1.9 | 1.0 | <1.0 | 720 | 19 | 0.44 | 6.36 |
| | | 85% | 5.9 | 1.8 | 1.5 | 770 | 32 | -.63 | 8.47 |
| IV | | | | | | | | | |
| | 73 l/m2 (1.5 gal/ft$^2$) | 15% | 0.8 | 2.3 | - | 649 | <30 | 0.16 | 2.70 |
| | | 50% | 2.3 | 5.2 | - | 776 | <30 | 0.17 | 4.27 |
| | | 85% | 6.5 | 10.0 | - | 928 | <30 | 0.19 | 6.75 |

* Period I Sept. 28, 1969 to July 23, 1970
Period II Jul. 27 1970 to March 2, 1971
Period III March 3, 1971 to Nov. 17, 1971
Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l.

## TABLE NO.13

Statistical Analysis Effluent Quality

Filter Bed No.5
$D_{10}$ = 1.0 mm $C_u$ = 2.1

| *Period | Daily Loading Rate | Samples | **Values Equal to or Less than Free Ammonia N. | Organic N | Nitrite N | Nitrate N | Total Coliform | Fecal |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| | | 15% | 0.30 | 0.17 | 0.10 | 16 | 0.34 | 0.13 |
| | 49 l/m$^2$ (1 gal/ft$^2$) | 50% | 4.0 | 0.42 | 0.40 | 25 | 40 | 7.0 |
| | | 85% | 13.0 | 1.05 | 1.60 | 37 | 4300 | 450 |
| II | | | | | | | | |
| | | 15% | N.D. | 0.26 | 0.03 | 19 | 0.19 | 0.09 |
| | 49 l/m$^2$ (1 gal/ft$^2$) | 50% | 0.1 | 0.41 | 0.14 | 31 | 6.6 | 3.00 |
| | | 85% | 5.6 | 0.63 | 0.73 | 50 | 250 | 100 |
| III | | | | | | | | |
| | | 15% | N.D. | 0.32 | 0.01 | 15.5 | 0.63 | 0.07 |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 50% | N.D. | 0.39 | 0.02 | 25.5 | 57 | 6.50 |
| | | 85% | 1.1 | 0.48 | 0.21 | 42.5 | 5200 | 600 |
| IV | | | | | | | | |
| | | 15% | 0.02 | 0.49 | 0.02 | 10.3 | 35 | 6.64 |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 50% | 0.18 | 0.81 | 0.05 | 17.0 | 575 | 73.2 |
| | | 85% | 1.4 | 0.92 | 0.11 | 28.2 | 9430 | 807 |

* Period I Sept. 28, 1969 to July 23, 1970 Period III March 3, 1971 to Nov. 17, 1971.
Period II Jul 27, 1970 to March 2, 1971 Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l except Coliforms in thousands/100 ml.

TABLE NO.14

Statistical Analysis Effluent Quality

Filter Bed No.6 $D_{10}$ = 2.5 mm $C_u$ = 1.2

| *Period | Daily Loading Rate | Samples | ** Values Equal to or less than $BOD_5$ | Suspended Solids | Volatile Sus-solids | Total Solids | COD | MBAS | Total Phos. P |
|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | |
| | 49 $l/m^2$ (1 gal/$ft^2$) | 15% | 2.7 | 1.8 | - | 540 | 26 | 0.31 | 7.50 |
| | | 50% | 5.2 | 4.3 | - | 660 | 45 | 0.55 | 10.76 |
| | | 85% | 10.0 | 10.5 | - | 800 | 78 | 0.96 | 15.65 |
| II | | | | | | | | | |
| | 49 $l/m^2$ (1 gal/$ft^2$) | 15% | 1.8 | < 1.0 | < 1.0 | 545 | 23 | 0.36 | 7.50 |
| | | 50% | 3.8 | 2.3 | 1.0 | 620 | 39 | 0.61 | 11.90 |
| | | 85% | 8.0 | 7.6 | 4.3 | 715 | 64 | 1.00 | 18.91 |
| III | | | | | | | | | |
| | 73 $l/m^2$ (1.5 gal/$ft^2$) | 15% | 2.5 | 1.5 | 1.4 | 580 | 14 | 0.31 | 4.08 |
| | | 50% | 5.4 | 3.7 | 2.7 | 660 | 25 | 0.58 | 6.03 |
| | | 85% | 13.0 | 9.1 | 5.2 | 760 | 44 | 1.10 | 9.13 |
| IV | | | | | | | | | |
| | 73 $l/m^2$ (1.5 gal/$ft^2$) | 15% | 1.8 | 3.0 | - | 618 | < 30 | o.18 | 2.71 |
| | | 50% | 5.4 | 9.0 | - | 752 | < 18 | 0.31 | 4.72 |
| | | 85% | 17.5 | 28.0 | - | 915 | 74 | 0.55 | 8.22 |

* Period I Sept. 28, 1969 to July 23, 1970 Period III March 3, 1971 to Nov. 17, 1971
Period II Jul. 27, 1970 to March 2, 1971 Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l.

## TABLE NO.15

Statistical Analysis Effluent Quality

Filter Bed No. 6
$D_{10}$ = 2.5 mm $C_u$ = 1.2

| *Period | Daily Loading Rate | Samples | **Values Equal to or Less than Free Ammonia N. | Organic N | Nitrite N | Nitrate N | Total Coliform | Fecal |
|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | |
| | | 15% | 2.9 | 0.31 | 0.26 | 11 | 10 | 2.2 |
| | 49 l/m$^2$ (1 gal/ft$^2$) | 50% | 8.8 | 0.76 | 0.64 | 16 | 540 | 38.0 |
| | | 85% | 27.0 | 1.90 | 1.60 | 24 | 8000 | 640 |
| II | | | | | | | | |
| | | 15% | 2.7 | 0.29 | 0.18 | 9.6 | 0.88 | 0.70 |
| | 49 l/m$^2$ (1 gal/ft2) | 50% | 4.9 | 0.48 | 0.39 | 21 | 67 | 31.0 |
| | | 85% | 8.9 | 0.80 | 0.85 | 45 | 6000 | 1500 |
| III | | | | | | | | |
| | | 15% | 0.03 | 0.25 | 0.08 | 10.3 | 3.5 | 0.93 |
| | 73 l/m$^2$ (1.5 gal/ft$^2$) | 50% | 1.05 | 0.35 | 0.32 | 21.8 | 45 | 36 |
| | | 85% | 4.70 | 0.48 | 1.20 | 37.0 | 13,000 | 1400 |
| IV | | | | | | | | |
| | | 15% | 0.87 | - | 0.03 | 4.4 | 210 | 33.2 |
| | 73 l/m2 (1.5 gal/ft$^2$) | 50% | 1.68 | 0.44 | 0.15 | 10.9 | 1891 | 241 |
| | | 85% | 3.23 | 6.64 | 0.69 | 27.1 | 17,051 | 1757 |

* Period I Sept. 28, 1969 to July 23, 1970
Period II Jul. 27, 1970 to March 2, 1971
Period III March 3, 1971 to Nov. 17, 1971.
Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l except Coliforms in thousands/100 ml.

TABLE NO. 16

Statistical Analysis Effluent Quality — Septic Tank Effluent

| *Period | Daily Loading Rate | Samples | ** Values Equal to or less than $BOD_5$ | Suspended Solids | Volatile Sus-solids | Total Solids | COD | MBAS | Total Phos. P |
|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | |
| | N.A. | 15% | 43 | 45 | - | 550 | 82 | 2.2 | 6.52 |
| | | 50% | 86 | 72 | - | 660 | 180 | 3.3 | 12.06 |
| | | 85% | 170 | 180 | - | 790 | 400 | 5.0 | 22.17 |
| II | | | | | | | | | |
| | N.A. | 15% | 58 | 28 | 9.5 | 520 | 140 | 5.0 | 8.64 |
| | | 50% | 135 | 65 | 28.5 | 580 | 245 | 7.6 | 13.53 |
| | | 85% | 310 | 153 | 92.0 | 660 | 435 | 11.8 | 21.51 |
| III | | | | | | | | | |
| | N.A. | 15% | 53 | 29 | 25.0 | 590 | 110 | 3.1 | 4.82 |
| | | 50% | 110 | 64 | 57.0 | 682 | 190 | 5.8 | 7.89 |
| | | 85% | 230 | 142 | 1300 | 790 | 335 | 10.9 | 13.36 |
| IV | | | | | | | | | |
| | | 15% | 19 | 18 | - | 595 | 49 | 1.5 | 2.03 |
| | | 50% | 55 | 44 | - | 747 | 126 | 3.5 | 4.92 |
| | | 85% | 159 | 104 | - | 939 | 327 | 7.9 | 12.0 |

* Period I Sept. 28, 1969 to July 23, 1970 — Period III March 3, 1971 to Nov. 17, 1971
Period II Jul. 27, 1970 to March 2, 1971 — Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l.

TABLE NO. 17

Septic Tank Effluent

Statistical Analysis Effluent Quality

| *Period | Daily Loading Rate | Samples | **Values Equal to or Less than | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Free Ammonia N. | Organic N | Nitrite N | Nitrate N | Total Coliform | Fecal |
| I | | | | | | | | |
| | | 15% | 17.0 | 1.3 | 0.001 | 0.1 | 7,400 | 250 |
| | N.A. | 50% | 26.0 | 1.8 | 0.001 | 0.1 | 8,000 | 800 |
| | | 85% | 40.0 | 2.5 | 0.015 | 1.0 | 8,000 | 800 |
| II | | | | | | | | |
| | | 15% | 14.3 | 0.8 | 0.001 | 0.1 | 2,100 | 730 |
| | N.A. | 50% | 23.0 | 1.7 | 0.001 | 0.1 | 9,100 | 2,200 |
| | | 85% | 37.0 | 3.5 | 0.092 | 0.9 | 42,000 | 6,600 |
| III | | | | | | | | |
| | | 15% | 9.8 | 0.7 | 0.001 | 0.1 | 2,550 | 500 |
| | N.A. | 50% | 12.2 | 0.9 | 0.001 | 0.1 | 21,500 | 2,600 |
| | | 85% | 15.5 | 1.2 | 0.007 | 3.7 | 80,000 | 8,000 |
| IV | | | | | | | | |
| | | 15% | 5.3 | - | 0.013 | 0.1 | 2,185 | 302 |
| | N.A. | 50% | 12.2 | - | 0.042 | 0.1 | 7,636 | 1,047 |
| | | 85% | 27.9 | 14,0 | 0.140 | 1.2 | 26,585 | 3,622 |

* Period I Sept. 28, 1969 to July 23, 1970 Period III March 3, 1971 to Nov. 17, 1971.
Period II Jul.27, 1970 to March 2, 1971 Period IV Nov. 18, 1971 to March 12, 1973.

** All Values in mg/l except Coliforms in thousands/100 ml.

TABLE NO 18

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY $BOD_5$ mg/l

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD | | | | 50% PERIOD | | | | 85% PERIOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Septic Tank | 43.0 | 58.0 | 53.0 | 18.8 | 86.0 | 135 | 110.0 | 54.6 | 170 | 310 | 230 | 159 |
| Filter Bed 1 | - | 0.5 | 0.8 | 0.6 | - | 1.7 | 2.7 | 1.5 | - | 5.5 | 8.4 | 3.9 |
| Filter Bed 2 | 1.2 | 3.8 | 0.9 | 0.4 | 2.9 | 6.1 | 2.9 | 1.0 | 7.0 | 9.5 | 9.4 | 2.3 |
| Filter Bed 3 | 1.2 | 0.9 | 0.9 | 0.6 | 3.2 | 2.6 | 2.7 | 1.5 | 8.6 | 8.1 | 8.8 | 3.5 |
| Filter Bed 4 | - | 0.3 | 2.0 | 0.6 | - | 1.4 | 4.1 | 1.1 | - | 7.4 | 8.5 | 2.0 |
| Filter Bed 5 | 1.2 | 0.6 | 0.6 | 0.8 | 2.8 | 1.6 | 1.9 | 2.3 | 6.2 | 4.3 | 5.9 | 6.5 |
| Filter Bed 6 | 2.7 | 1.7 | 2.5 | 1.7 | 5.2 | 3.8 | 5.7 | 5.4 | 10.0 | 8.0 | 13.0 | 17.5 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 19

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY

COD mg/l

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD | | | | 50% PERIOD | | | | 85% PERIOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Septic Tank | 82 | 140 | 110 | 48.5 | 180 | 245 | 190 | 126 | 400 | 435 | 335 | 327 |
| Filter Bed 1 | - | 19 | 17 | <30 | - | 27 | 25 | 9.2 | - | 39 | 37 | 30 |
| Filter Bed 2 | 21 | 20 | 18 | 30 | 33 | 32 | 30 | 30 | 53 | 50 | 53 | 33 |
| Filter Bed 3 | 21 | 23 | 18 | <30 | 34 | 37 | 27 | 10.0 | 56 | 59 | 41 | 29.0 |
| Filter Bed 4 | - | 14 | 11 | <30 | - | 22 | 26 | 66 | - | 36 | 35 | 24 |
| Filter Bed 5 | 22 | 16 | 12 | <30 | 33 | 26 | 19 | <30 | 48 | 43 | 32 | 23 |
| Filter Bed 6 | 26 | 23 | 1- | <30 | 45 | 39 | 25 | <30 | 78 | 64 | 44 | 74 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 20

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY — Suspended Solids mg/l

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD I | 15% PERIOD II | 15% PERIOD III | 15% PERIOD IV | 50% PERIOD I | 50% PERIOD II | 50% PERIOD III | 50% PERIOD IV | 85% PERIOD I | 85% PERIOD II | 85% PERIOD III | 85% PERIOD IV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank | 45.0 | 28.0 | 29.0 | 18.4 | 72.0 | 65.0 | 64.0 | 43.8 | 120.0 | 154 | 142 | 104 |
| Filter Bed 1 | - | <1.0 | <1.0 | 0.4 | - | <1.0 | <1.0 | 1.6 | - | 1.5 | 1.5 | 6.0 |
| Filter Bed 2 | <1.0 | <1.0 | <1.0 | <1.0 | 1.0 | <1.0 | 1.0 | 2.4 | 5.0 | 3.5 | 7.0 | 8.1 |
| Filter Bed 3 | <1.0 | <1.0 | <1.0 | 0.8 | <1.0 | 1.0 | <1.0 | 2.6 | 3.5 | 2.4 | 2.9 | 8.2 |
| Filter Bed 4 | - | <1.0 | 1.5 | 0.6 | - | 1.0 | 3.1 | 2.4 | - | 1.6 | 6.5 | 9.5 |
| Filter Bed 5 | <1.0 | 1.0 | <1.0 | 2.3 | 1.6 | 1.0 | <1.0 | 5.2 | 4.2 | 1.7 | 1.8 | 10.0 |
| Filter Bed 6 | 1.8 | 1.0 | 1.5 | 3.1 | 4.3 | 2.3 | 3.7 | 9.4 | 10.5 | 7.6 | 9.1 | 28.0 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 21

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY — Volatile Suspended Solids mg/l

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD I | II | III | IV | 50% PERIOD I | II | III | IV | 85% PERIOD I | II | III | IV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank | - | 9.5 | 25.0 | | - | 28.5 | 57.0 | | - | 92.0 | 130 | |
| Filter Bed 1 | - | <1.0 | <1.0 | | - | <1.0 | <1.0 | | - | <1.0 | 1.4 | |
| Filter Bed 2 | - | <1.0 | <1.0 | | - | 1.0 | <1.0 | | - | <1.0 | 4.2 | |
| Filter Bed 3 | - | <1.0 | <1.0 | | - | <1.0 | <1.0 | | - | 1.5 | 2.0 | |
| Filter Bed 4 | - | < 1.0 | 1.0 | | - | <1.0 | 2.0 | | - | <1.0 | 3.9 | |
| Filter Bed 5 | - | < 1.0 | < 1.0 | | - | <1.0 | <1.0 | | - | <1.0 | 1.5 | |
| Filter Bed 6 | - | < 1.0 | 1.4 | | - | 1.1 | 2.7 | | - | 4.3 | 5.2 | |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 22

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY Free Ammonia N mg/l

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD I | II | III | IV | 50% PERIOD I | II | III | IV | 85% PERIOD I | II | III | IV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank | 17.00 | 14.30 | 9.80 | 5.33 | 26.00 | 23.00 | 12.20 | 12.20 | 40.00 | 37.00 | 15.50 | 27.9 |
| Filter Bed 1 | - | N.D. | N.D. | 0.015 | - | 0.06 | 0.06 | 0.06 | - | 1.70 | 1.50 | 0.25 |
| Filter Bed 2 | 4.00 | 2.10 | N.D. | 0.03 | 3.1 | 3.30 | 0.18 | 0.15 | 15.00 | 9.40 | 2.85 | 0.79 |
| Filter Bed 3 | 0.10 | N.D. | N.D. | 0.021 | 0.10 | 1.03 | N.D. | 0.115 | 8.00 | 8.00 | 6.20 | 0.62 |
| Filter Bed 4 | - | N.D. | N.D. | 0.027 | - | N.D. | 0.01 | 0.080 | - | 2.30 | 1.50 | 0.29 |
| Filter Bed 5 | 0.30 | N.D. | N.D. | 0.024 | 4.00 | 0.11 | N.D. | 0.18 | 13.00 | 5.60 | 1.10 | 1.40 |
| Filter Bed 6 | 2.90 | 2.70 | 0.03 | 0.873 | 8.80 | 4.90 | 1.05 | 1.68 | 27.00 | 8.80 | 4.70 | 3.23 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 23

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY Organic N mg/l

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD | | | | 50% PERIOD | | | | 85% PERIOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Septic Tank | 1.30 | 0.80 | 0.70 | - | 1.80 | 1.70 | 0.93 | - | 2.50 | 3.50 | 1.23 | 14.0 |
| Filter Bed 1 | - | 0.23 | 0.28 | 0.31 | - | 0.38 | 0.38 | 0.64 | - | 0.62 | 0.50 | 1.25 |
| Filter Bed 2 | 0.30 | 0.29 | 0.28 | 0.27 | 0.52 | 0.48 | 0.39 | 0.56 | 0.88 | 0.80 | 0.55 | 0.88 |
| Filter Bed 3 | 0.17 | 0.28 | 0.28 | 0.31 | 0.35 | 0.42 | 0.40 | 0.57 | 0.76 | 0.64 | 0.57 | 0.78 |
| Filter Bed 4 | - | 0.17 | 0.44 | 0.30 | - | 0.31 | 0.52 | 0.50 | - | 0.57 | 0.60 | 0.75 |
| Filter Bed 5 | 0.17 | 0.26 | 0.32 | 0.49 | 0.42 | 0.41 | 0.39 | 0.81 | 1.05 | 0.63 | 0.48 | 0.92 |
| Filter Bed 6 | 0.31 | 0.29 | 0.25 | - | 0.76 | 0.48 | 0.35 | 0.44 | 1.90 | 0.80 | 0.48 | 6.64 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 24

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY — Nitrite N mg/l

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD I | 15% PERIOD II | 15% PERIOD III | 15% PERIOD IV | 50% PERIOD I | 50% PERIOD II | 50% PERIOD III | 50% PERIOD IV | 85% PERIOD I | 85% PERIOD II | 85% PERIOD III | 85% PERIOD IV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank | 0.001 | 0.001 | 0.001 | 0.013 | 0.001 | 0.001 | 0.001 | 0.042 | 0.015 | 0.092 | 0.007 | 0.140 |
| Filter Bed 1 | - | 0.020 | 0.005 | 0.015 | - | 0.170 | 0.050 | 0.017 | - | 1.00 | 0.53 | 0.019 |
| Filter Bed 2 | 0.160 | 0.330 | 0.014 | 0.021 | 0.30 | 0.052 | 0.110 | 0.027 | 0.60 | 0.66 | 0.87 | 0.036 |
| Filter Bed 3 | 0.190 | 0.084 | 0.003 | 0.017 | 0.60 | 0.260 | 0.032 | 0.035 | 1.90 | 0.84 | 0.32 | 0.074 |
| Filter Bed 4 | - | 0.003 | 0.012 | 0.016 | - | 0.080 | 0.021 | 0.024 | - | 1.80 | 0.70 | 0.037 |
| Filter Bed 5 | 0.100 | 0.03 | 0.002 | 0.025 | 0.40 | 0.140 | 0.020 | 0.051 | 1.60 | 0.73 | 0.21 | 0.108 |
| Filter Bed 6 | 0.260 | 0.180 | 0.082 | 0.032 | 0.64 | 0.390 | 0.320 | 0.15 | 1.60 | 0.85 | 1.20 | 0.69 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 25

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY — Nitrate N mg/l

V A L U E S

15%, 50% and 85%

of time equal to or less than

| Effluent From | 15% PERIOD | | | | 50% PERIOD | | | | 85% PERIOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Septic Tank | 0.1 | 0.1 | 0.1 | 0.011 | 0.1 | 0.1 | 0.1 | 0.115 | 1.0 | 0.9 | 3.7 | 1.20 |
| Filter Bed 1 | - | 20.0 | 16.5 | 11.4 | - | 32.0 | 25.0 | 18.1 | - | 52.0 | 38.0 | 28.0 |
| Filter Bed 2 | 12.0 | 17.0 | 13.0 | 7.20 | 19.0 | 26.0 | 23.5 | 14.1 | 28.0 | 39.0 | 43.0 | 27.7 |
| Filter Bed 3 | 19.0 | 20.0 | 19.0 | 12.3 | 27.0 | 32.0 | 27.0 | 18.9 | 40.0 | 52.0 | 39.0 | 28.9 |
| Filter Bed 4 | - | 29.0 | 18.0 | 11.9 | - | 40.0 | 26.0 | 17.6 | - | 66.0 | 37.0 | 26.0 |
| Filter Bed 5 | 16.0 | 19.0 | 15.5 | 10.3 | 25.0 | 31.0 | 25.5 | 17.0 | 37.0 | 50.0 | 42.5 | 28.2 |
| Filter Bed 6 | 11.0 | 9.6 | 10.3 | 4.41 | 16.0 | 21.0 | 21.8 | 10.9 | 24.0 | 45.0 | 37.0 | 27.1 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 26

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY

Phosphorus (P) mg/l

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD | | | | 50% PERIOD | | | | 85% PERIOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Septic Tank | 6.5 | 8.6 | 4.8 | 2.0 | 12.1 | 13.5 | 7.9 | 4.9 | 22.2 | 21.5 | 13.4 | 12.0 |
| Filter Bed 1 | - | 1.2 | 1.1 | 0.8 | - | 1.6 | 1.8 | 1.7 | - | 2.4 | 2.7 | 3.1 |
| Filter Bed 2 | 5.9 | 8.2 | 3.0 | 2.2 | 9.8 | 10.8 | 5.2 | 3.6 | 16.3 | 14.4 | 8.8 | 5.8 |
| Filter Bed 3 | 8.2 | 8.2 | 4.1 | 2.6 | 11.4 | 12.1 | 5.7 | 4.2 | 16.3 | 17.6 | 8.2 | 6.8 |
| Filter Bed 4 | - | 7.0 | 4.2 | 2.7 | - | 9.1 | 4.6 | 4.1 | - | 11.9 | 5.1 | 6.4 |
| Filter Bed 5 | 6.5 | 8.3 | 4.7 | 2.7 | 9.8 | 11.7 | 6.4 | 4.3 | 5.3 | 17.3 | 8.5 | 6.8 |
| Filter Bed 6 | 7.5 | 7.5 | 4.1 | 2.7 | 10.8 | 11.9 | 6.0 | 4.7 | 15.7 | 18.9 | 9.1 | 8.2 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 27

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY MBAS mg/l

V A L U E S

15%, 50% and 85%

of time equal to or less than

| Effluent From | 15% PERIOD | | | | 50% PERIOD | | | | 85% PERIOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Septic Tank | 2.20 | 5.00 | 3.10 | 1.52 | 3.30 | 7.60 | 5.80 | 3.47 | 5.00 | 11.80 | 10.90 | 7.92 |
| Filter Bed 1 | - | 0.28 | 0.29 | 0.08 | - | 0.47 | 0.43 | 0.16 | - | 0.79 | 0.62 | 0.29 |
| Filter Bed 2 | 0.20 | 0.33 | 0.29 | 0.14 | 0.54 | 0.64 | 0.43 | 0.16 | 1.50 | 1.25 | 0.65 | 0.19 |
| Filter Bed 3 | 0.27 | 0.36 | 0.31 | 0.09 | 0.48 | 0.66 | 0.47 | 0.16 | 0.86 | 1.20 | 0.72 | 0.31 |
| Filter Bed 4 | - | 0.30 | 0.27 | | - | 0.45 | 0.39 | | - | 0.65 | 0.55 | |
| Filter Bed 5 | 0.24 | 0.30 | 0.30 | 0.16 | 0.50 | 0.50 | 0.44 | 0.17 | 1.00 | 0.84 | 0.63 | 0.19 |
| Filter Bed 6 | 0.31 | 0.36 | 0.31 | 0.18 | 0.55 | 0.61 | 0.58 | 0.31 | 0.96 | 1.00 | 1.10 | 0.55 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 28

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY — Total Solids mg/l

V A L U E S

15%, 50% and 85%

of time equal to or less than

| Effluent From | 15% PERIOD I | II | III | IV | 50% PERIOD I | II | III | IV | 85% PERIOD I | II | III | IV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank | 550 | 520 | 590 | 595 | 660 | 580 | 682 | 747 | 790 | 660 | 790 | 939 |
| Filter Bed 1 | - | 640 | 680 | 682 | - | 700 | 750 | 808 | - | 780 | 820 | 956 |
| Filter Bed 2 | 630 | 600 | 620 | 619 | 730 | 740 | 730 | 780 | 880 | 900 | 870 | 1,028 |
| Filter Bed 3 | 600 | 580 | 640 | | 720 | 660 | 720 | | 880 | 760 | 790 | |
| Filter Bed 4 | - | 650 | 690 | 685 | - | 730 | 770 | 819 | - | 820 | 850 | 979 |
| Filter Bed 5 | 620 | 620 | 665 | 649 | 715 | 720 | 720 | 776 | 880 | 840 | 770 | 928 |
| Filter Bed 6 | 540 | 545 | 580 | 618 | 660 | 620 | 660 | 752 | 800 | 715 | 760 | 915 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 29

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY Total Coliforms in $10^3$ per 100 ml

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD | | | | 50% PERIOD | | | | 85% PERIOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Septic Tank | 7400 | 2100 | 2550 | 2185 | 8000 | 9100 | 21500 | 7636 | 8000 | 42000 | 80000 | 26685 |
| Filter Bed 1 | - | 0.06 | 0.14 | 0.38 | - | 0.71 | 34 | 4.74 | - | 8 | 840 | 59 |
| Filter Bed 2 | 0.66 | 0.40 | 0.10 | 0.62 | 90 | 10 | 10 | 10.9 | 600 | 110 | 970 | 191 |
| Filter Bed 3 | 0.52 | 0.95 | 0.67 | 13.7 | 35 | 30 | 46 | 226 | 2000 | 900 | 3100 | 3724 |
| Filter Bed 4 | - | 0.04 | 0.37 | 0.340 | - | 1.45 | 5.0 | 10.7 | - | 60 | 68 | 336 |
| Filter Bed 5 | 0.34 | 0.19 | 0.63 | 35 | 40 | 6.60 | 57 | 575 | 4300 | 250 | 5200 | 9430 |
| Filter Bed 6 | 10.00 | 0.88 | 3.50 | 210 | 540 | 67 | 45 | 1891 | 8000 | 6000 | 13000 | 17051 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO 30

SUMMARY OF STATISTICAL ANALYSIS

EFFLUENT QUALITY

Fecal Coliforms in $10^3$ per 100 ml

V A L U E S

15%, 50% and 85%
of time equal to or less than

| Effluent From | 15% PERIOD | | | | 50% PERIOD | | | | 85% PERIOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Septic Tank | 250 | 730 | 500 | 302 | 800 | 2200 | 2600 | 1047 | 800 | 6600 | 8000 | 3622 |
| Filter Bed 1 | - | 0.03 | 0.01 | 0.25 | - | 0.29 | 3.20 | 0.66 | - | 4.20 | 90 | 1.80 |
| Filter Bed 2 | 0.06 | 0.20 | 0.05 | 0.36 | 10 | 3.50 | 1.85 | 2.05 | 160 | 6.00 | 72 | 11.6 |
| Filter Bed 3 | 0.18 | 0.27 | 0.07 | 1.97 | 4.40 | 6.20 | 4.40 | 27.1 | 100 | 40 | 270 | 372 |
| Filter Bed 4 | - | 0.004 | 0.05 | 0.39 | - | 0.29 | 0.43 | 1.71 | - | 10.00 | 3.5 | 7.5 |
| Filter Bed 5 | 0.13 | 0.09 | 0.07 | 6.64 | 7.00 | 3.00 | 6.50 | 73.2 | 450.00 | 100.00 | 600 | 807 |
| Filter Bed 6 | 2.20 | 0.70 | 0.93 | 33.2 | 38.00 | 31.00 | 36.00 | 241 | 640 | 1500 | 1400 | 1757 |

Period I September 29, 1969 to July 23, 1970.

Period II July 27, 1970 to March 2, 1971.

Period III March 3, 1971 to Nov. 17, 1971.

Period IV Nov. 18, 1971 to March 12, 1973.

TABLE NO. 31
EFFLUENT QUALITY
STATISTICAL ANALYSIS

Filter Bed No. / Medium Sand

Sand with Red Mud $D_{10}$ = 0.24 mm

July 27, 1970 to March 12, 1973 $C_u$ = 3.9

| | Number of Tests | VALUES Percent of time equal to or less than 15% | 50% | 85% |
|---|---|---|---|---|
| BOD | 115 | 0.06 | 1.9 | 6.4 |
| COD | 118 | 19.5 | 28 | 40 |
| Suspended Solids | 119 | 0.6 | 1.5 | 3.6 |
| Total Solids | 120 | 660 | 771 | 902 |
| Free Ammonia (N) | 128 | 0.01 | 0.09 | 0.73 |
| Organic (N) | 129 | 0.73 | 0.44 | 0.85 |
| Nitrite (N) | 128 | 0.005 | 0.032 | 0.216 |
| Nitrate (N) | 128 | 13.4 | 22.1 | 36.4 |
| MBAS | 129 | 0.12 | 0.25 | 0.53 |
| Total Phosphorus (P) | 129 | 0.95 | 1.6 | 2.7 |
| Total Coliform | 133 | 0.07 | 3.92 | 219 |
| Fecal Coliform | 133 | 0.023 | 0.601 | 15.62 |

* All values except coliforms in mg/l

Coliforms in thousands/100 ml.

TABLE NO. 32
EFFLUENT QUALITY
STATISTICAL ANALYSIS

Filter Bed No. 2

Block Sand
$D_{10}$ = 0.30 mm

Sept. 28, 1969 to March 12, 1973

$C_u$ = 4.1

| | Number of Tests | VALUES Percent of time equal to or less than 15% | 50% | 85% |
|---|---|---|---|---|
| BOD | 174 | 0.7 | 2.4 | 8.0 |
| COD | 178 | 20 | 31 | 50 |
| Suspended Solids | 181 | 0.7 | 1.7 | 4.9 |
| Total Solids | 181 | 600 | 751 | 941 |
| Free Ammonia (N) | 182 | 0.06 | 0.74 | |
| Organic (N) | 181 | 0.23 | 0.46 | 0.92 |
| Nitrite (N) | 181 | 0.016 | 0.107 | 0.711 |
| Nitrate (N) | 183 | 6.4 | 16.0 | 40.2 |
| MBAS | 170 | 0.14 | 0.35 | 0.92 |
| Total Phosphorus (P) | 180 | 2.9 | 5.8 | 11.8 |
| Total Coliform | 188 | 0.52 | 15.1 | 437.5 |
| Fecal Coliform | 184 | 0.35 | 2.98 | 25.6 |

* All values except coliforms in mg/l

Coliforms in thousands/100 ml.

TABLE NO. 33
EFFLUENT QUALITY
STATISTICAL ANALYSIS
Filter Bed No. 3
Sept. 28, 1969 to March 12, 1973

Foundry Slag
$D_{10}$ = 0.60 mm
$C_u$ = 2.7

| | Number of Tests | VALUES Percent of time equal to or less than 15% | 50% | 85% |
|---|---|---|---|---|
| BOD | 175 | 0.8 | 2.3 | 6.6 |
| COD | 178 | 20 | 32 | 50 |
| Suspended Solids | 176 | 0.7 | 1.9 | 5.0 |
| Total Solids | 180 | 569 | 704 | 872 |
| Free Ammonia (N) | 181 | N.D. | 0.27 | 5.12 |
| Organic (N) | 178 | 0.25 | 0.46 | 0.87 |
| Nitrite (N) | 181 | 0.009 | 0.081 | 0.70 |
| Nitrate (N) | 183 | 8.4 | 19.9 | 47.2 |
| MBAS | 171 | 0.14 | 0.34 | 0.78 |
| Total Phosphorus (P) | 178 | 3.5 | 7.0 | 14.0 |
| Total Coliform | 186 | 2.59 | 67.78 | 1776 |
| Fecal Coliform | 186 | 1.04 | 9.01 | 78.0 |

* All values except coliforms in mg/l

Coliforms in thousands/100 ml.

TABLE NO. 34
EFFLUENT QUALITY
STATISTICAL ANALYSIS
Filter Bed No. 4
July 27, 1970 to March 12, 1973

Medium Sand
$D_{10}$ =0.24 mm
$C_u$ =3.9

| | Number of Tests | VALUES Percent of time equal to or less than 15% | 50% | 85% |
|---|---|---|---|---|
| BOD | 84 | 0.6 | 1.3 | 3.1 |
| COD | 82 | 72 | 28 | 35 |
| Suspended Solids | 84 | 0.7 | 2.3 | 7.8 |
| Total Solids | 89 | 672 | 793 | 936 |
| Free Ammonia (N) | 89 | 0.01 | 0.08 | 0.50 |
| Organic (N) | 86 | 0.25 | 0.43 | 0.75 |
| Nitrite (N) | 87 | 0.007 | 0.032 | 0.143 |
| Nitrate (N) | 89 | 13.2 | 21.7 | 35.6 |
| MBAS | 88 | 0.10 | 0.20 | 0.40 |
| Total Phosphorus (P) | 87 | 2.8 | 4.8 | 8.0 |
| Total Coliform | 94 | 0.339 | 17.67 | 920.6 |
| Fecal Coliform | 94 | 0.06 | 1.54 | 39.3 |

* All values except coliforms in mg/l

Coliforms in thousands/100 ml.

TABLE NO. 35
EFFLUENT QUALITY
STATISTICAL ANALYSIS

Filter Bed No. 5 — Fine Gravel with Sand

Sept. 28, 1969 to March 12, 1973 — $D_{10}$ = 1.00 mm, $C_u$ = 2.1

| | Number of Tests | VALUES Percent of time equal to or less than 15% | 50% | 85% |
|---|---|---|---|---|
| BOD | 174 | 0.80 | 2.4 | 6.9 |
| COD | 169 | 17 | 28 | 44 |
| Suspended Solids | 173 | 0.9 | 2.4 | 6.5 |
| Total Solids | 178 | 582 | 721 | 892 |
| Free Ammonia (N) | 178 | 0.017 | 0.324 | 6.23 |
| Organic (N) | 176 | 0.23 | 0.53 | 1.12 |
| Nitrite (N) | 175 | 0.011 | 0.082 | 0.604 |
| Nitrate (N) | 170 | 12.4 | 21.6 | 37.5 |
| MBAS | 164 | 0.15 | 0.34 | 0.74 |
| Total Phosphorus (P) | 176 | 3.7 | 7.6 | 15.8 |
| Total Coliform | 185 | 2.17 | 85.23 | 33.51 |
| Fecal Coliform | 181 | 0.675 | 12.957 | 248.68 |

* All values except coliforms in mg/l

Coliforms in thousands/100 ml.

TABLE NO. 36
EFFLUENT QUALITY
STATISTICAL ANALYSIS
Filter Bed No. 6
Sept. 28, 1969 to March 12, 1973

¼" Gravel
$D_{10}$= 2.50 mm
$C_u$ = 1.2

| | Number of Tests | VALUES Percent of time equal to or less than 15% | 50% | 85% |
|---|---|---|---|---|
| BOD | 170 | 2.1 | 5.8 | 15.7 |
| COD | 165 | 22 | 36 | 60 |
| Suspended Solids | 170 | 2.1 | 5.7 | 15.4 |
| Total Solids | 175 | 550 | 673 | 825 |
| Free Ammonia (N) | 177 | 0.34 | 2.29 | 15.27 |
| Organic (N) | 169 | 0.28 | 0.68 | 1.63 |
| Nitrite (N) | 175 | 0.065 | 0.280 | 1.213 |
| Nitrate (N) | 176 | 4.4 | 12.9 | 37.4 |
| MBAS | 168 | 0.20 | 0.48 | 1.14 |
| Total Phosphorus (P) | 173 | 3.1 | 5.8 | 11.0 |
| Total Coliform | 184 | 25.48 | 502.9 | 9924 |
| Fecal Coliform | 182 | 4.36 | 65.5 | 984.9 |

* All values except coliforms in mg/l

Coliforms in thousands/100 ml.

TABLE NO. 37
EFFLUENT QUALITY
STATISTICAL ANALYSIS

Septic Tank
Sept. 28, 1969 to March 12, 1973.

| | Number of Tests | VALUES Percent of time equal to or less than 15% | 50% | 85% |
|---|---|---|---|---|
| BOD | 174 | 29.9 | 77.6 | 202 |
| COD | 190 | 85.6 | 171 | 342 |
| Suspended Solids | 173 | 29.5 | 54.7 | 101.5 |
| Total Solids | 192 | 516 | 650 | 818 |
| Free Ammonia (N) | 193 | 7.9 | 10.7 | 35.3 |
| Organic (N) | 193 | 0.82 | 1.98 | 4.79 |
| Nitrite (N) | 182 | 0.001 | 0.006 | 0.050 |
| Nitrate (N) | 186 | 0.072 | 0.197 | 0.543 |
| MBAS | 173 | 1.97 | 4.28 | 9.31 |
| Total Phosphorus (P) | 171 | 3.4 | 7.6 | 16.7 |
| Total Coliform | 185 | $2.47 \times 10^3$ | $8.86 \times 10^3$ | $317 \times 10^3$ |
| Fecal Coliform | 185 | 301 | 1047 | 3836 |

* All values except coliforms in mg/l

Coliforms in thousands/100 ml.

# APPENDIX I

## ANALYSIS OF RED MUD SAMPLES
(June 11, 1970)

# APPENDIX I

## Analyses of Red Mud Samples (June 11, 1970)

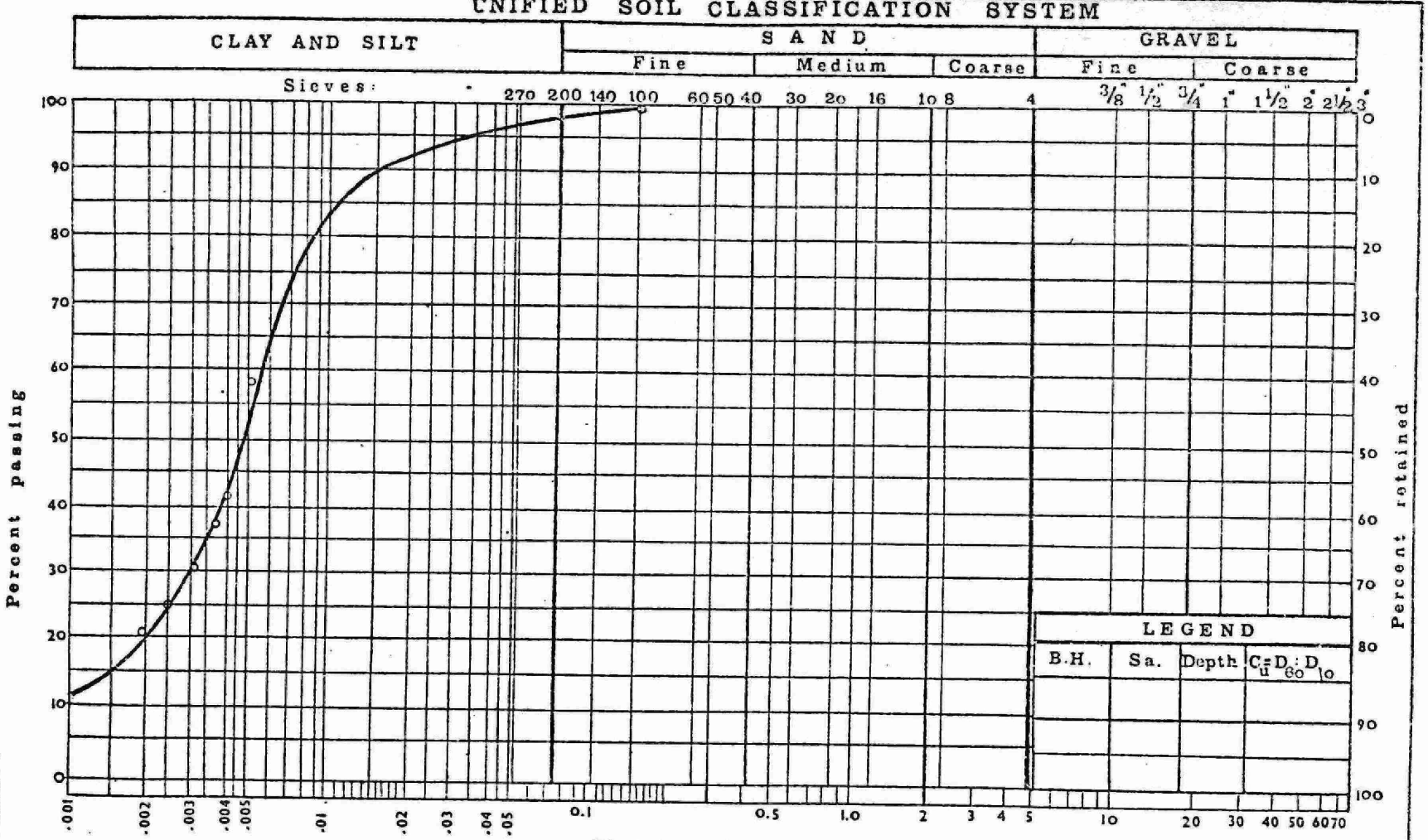
WHOLE MUD

| | |
|---|---|
| grams per liter solids | 332 |
| titrable soda as $Na_2CO_3$% | 11.6 |

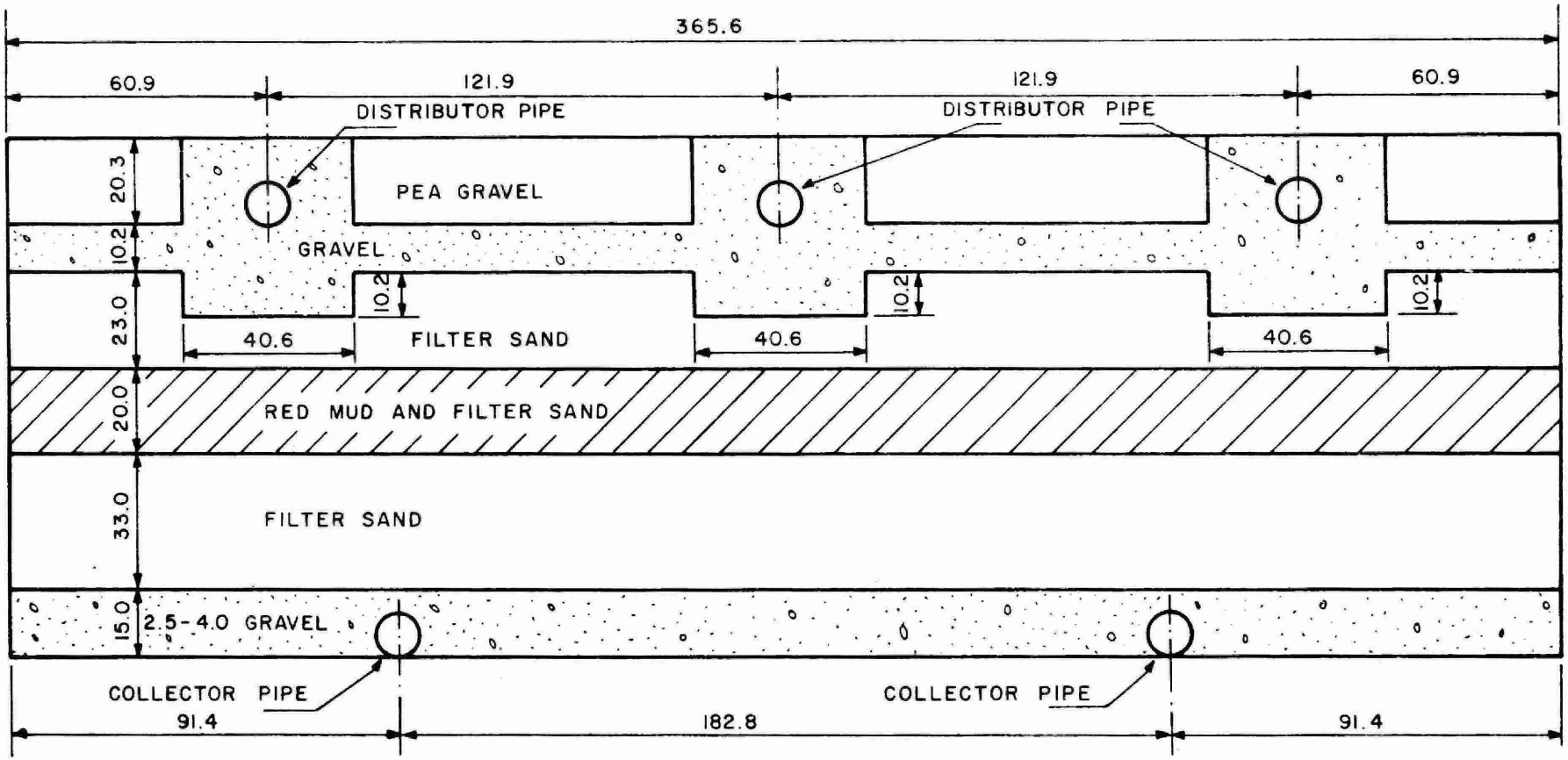
DRY BASIS (percent)

| | |
|---|---|
| $SiO_2$ | 16.7 |
| CaO | 2.5 |
| $Na_2O$ | 8.8 |
| $Al_2O_3$ | 22.7 |
| $Fe_2O_3$ | 25.7 |

# UNIFIED SOIL CLASSIFICATION SYSTEM




| | | |
|---|---|---|
| Ontario<br>Ministry of the Environment.<br>Private Waste & Water Management | GRAIN SIZE DISTRIBUTION<br>"RED MUD" | Job No:<br>Site: |




FILTER SAND $D_{10} = 0.24\,mm$

NOT TO SCALE

ALL MEASUREMENTS IN CENTIMETRES

MINISTRY OF THE ENVIRONMENT

POLLUTION CONTROL PLANNING BRANCH

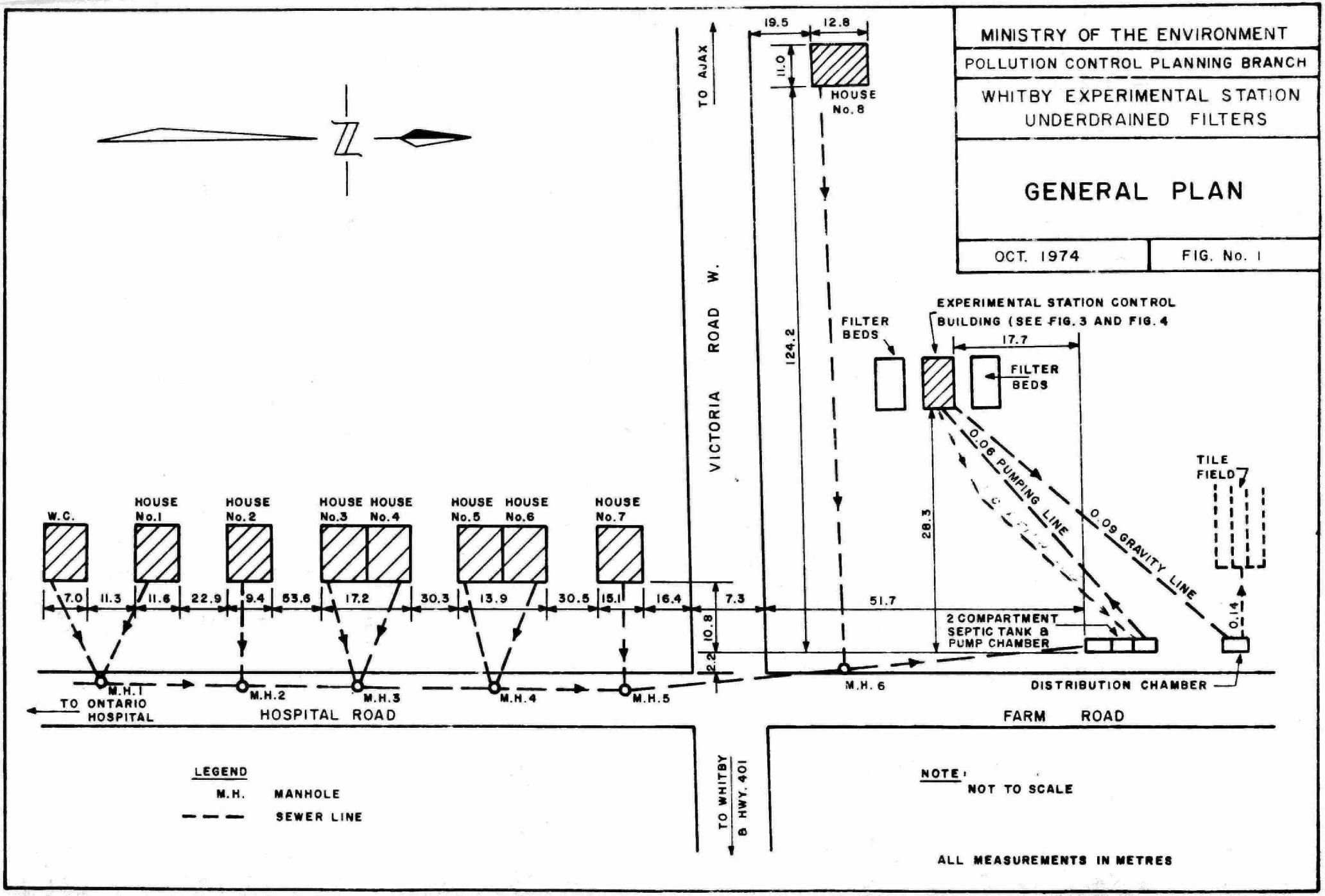
WHITBY EXPERIMENTAL STATION
UNDERDRAINED FILTERS

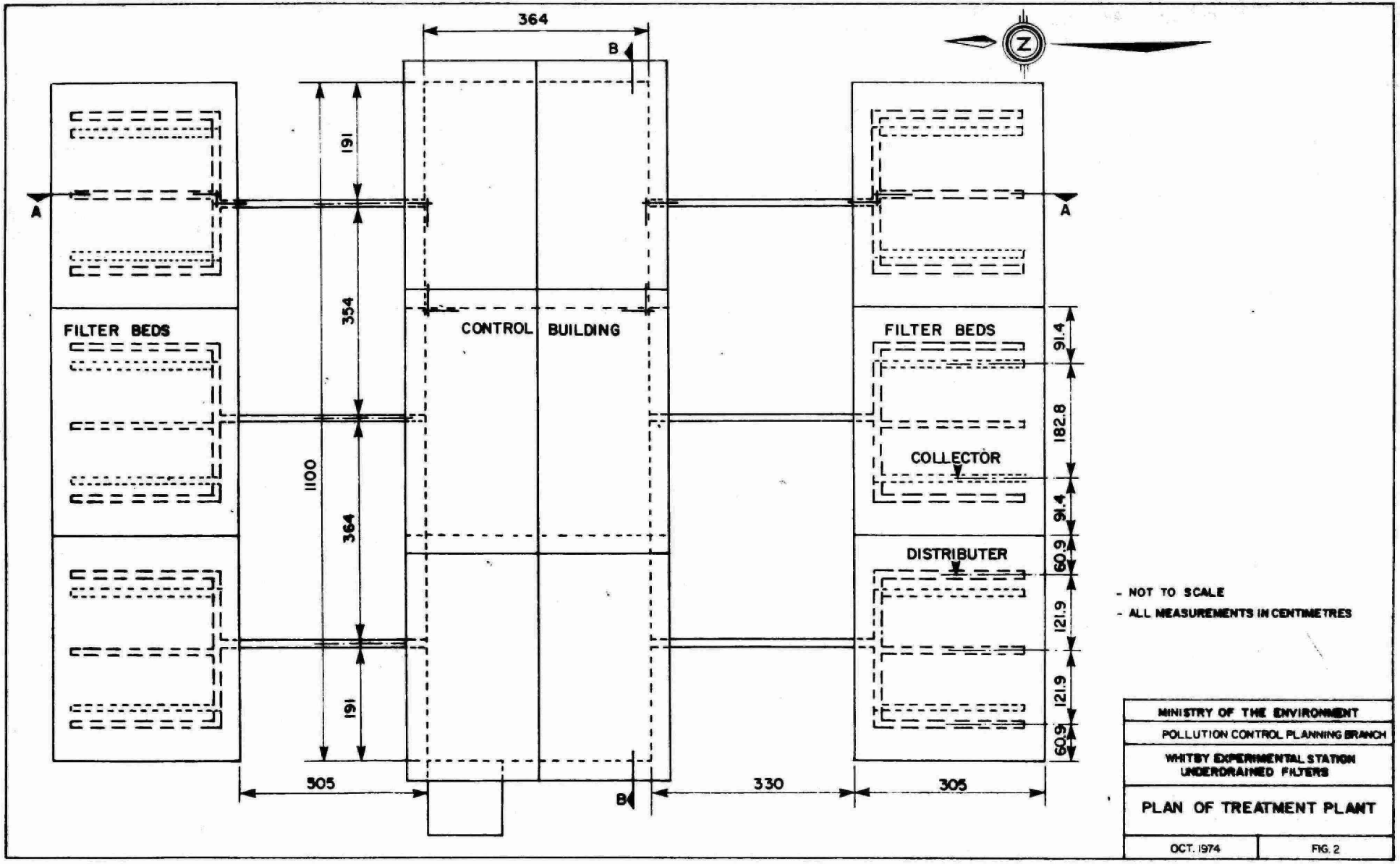
**DIAGRAM OF SECTION OF FILTER BED WITH SAND AND RED MUD**

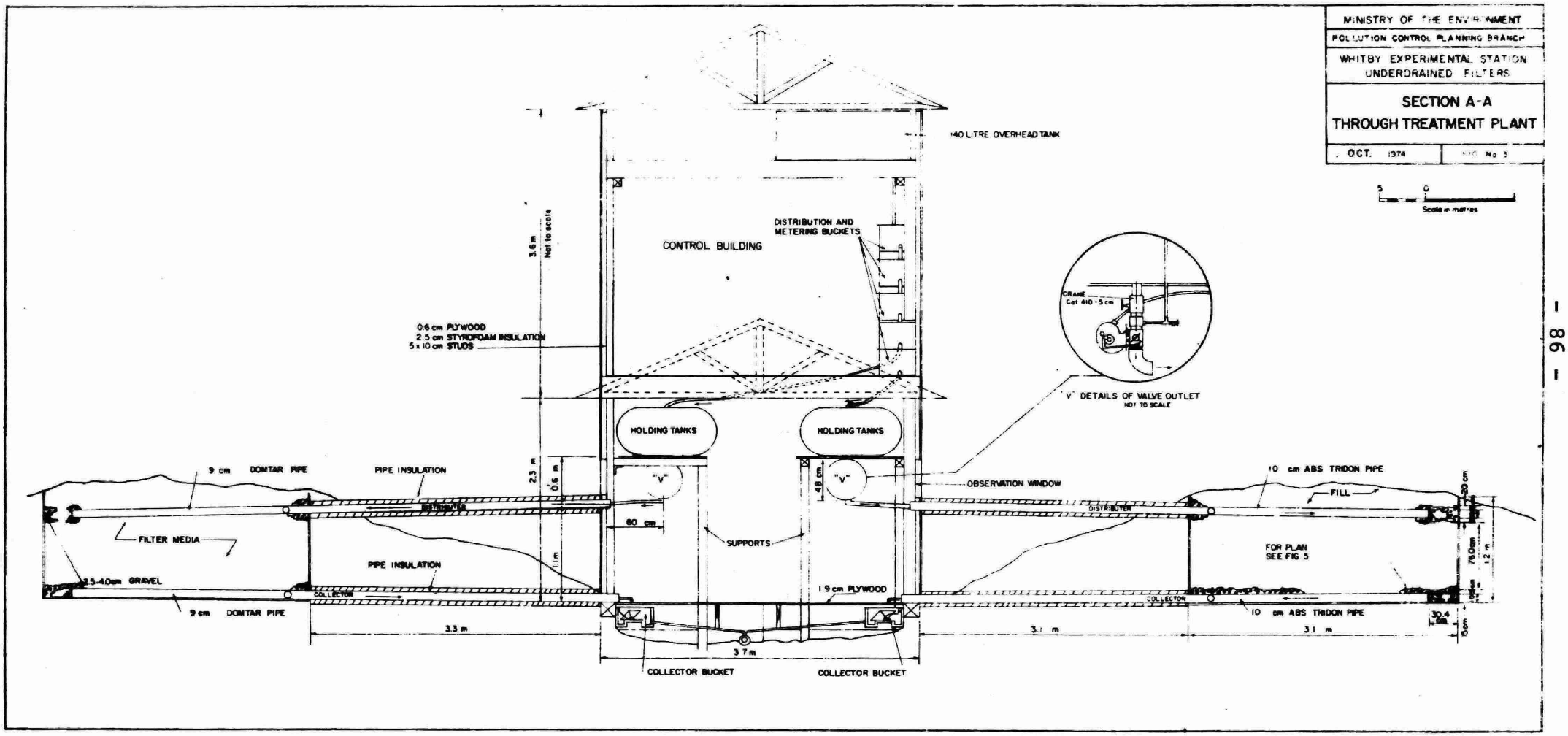
OCT. 1974

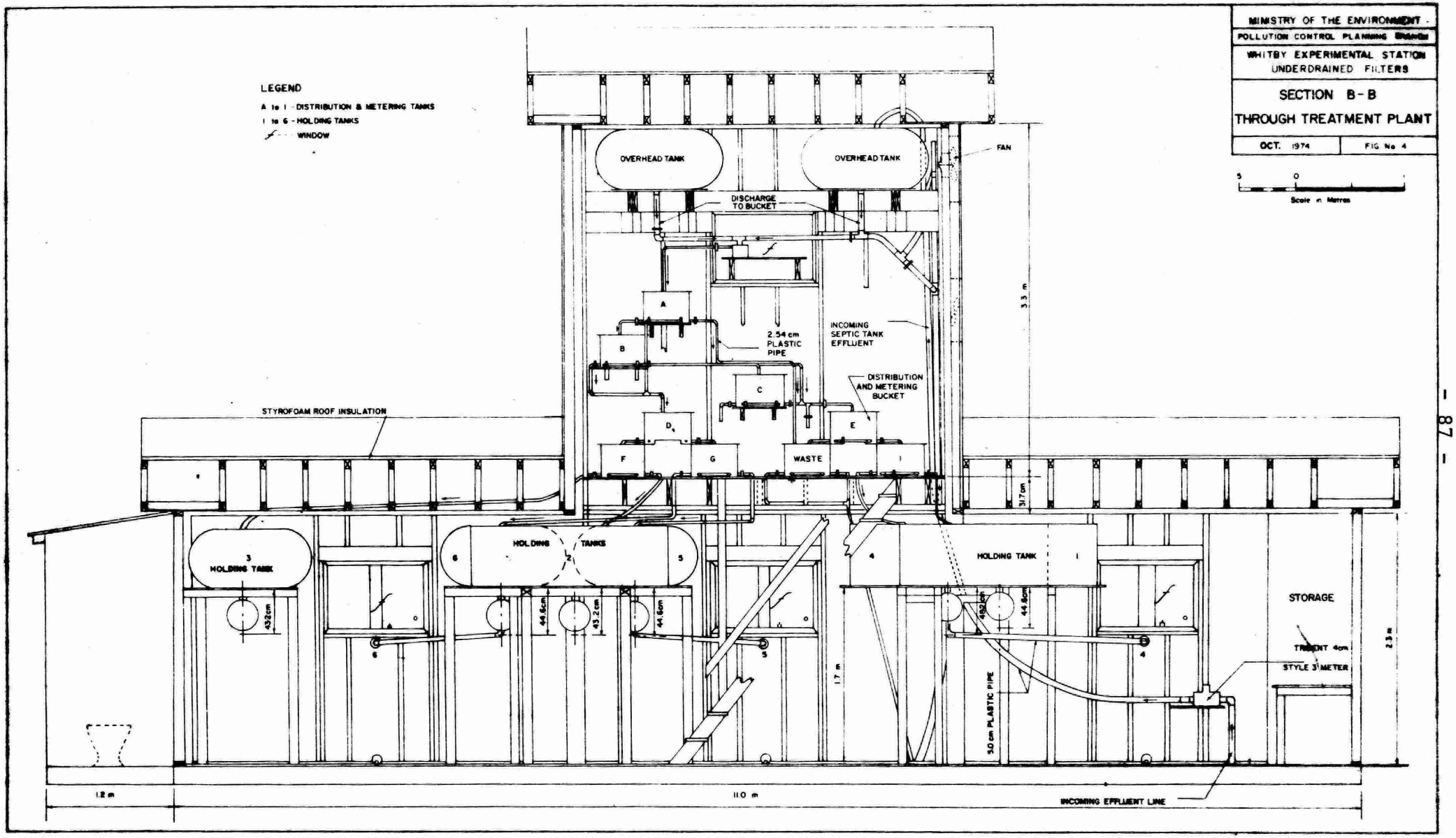
# APPENDIX II

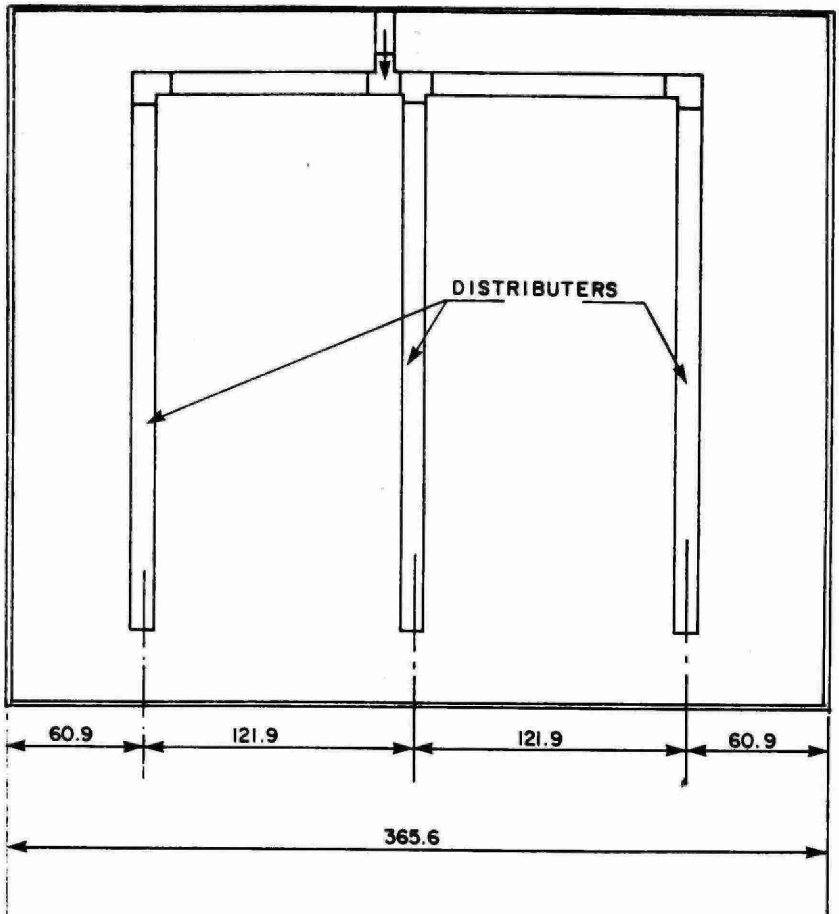
## LOCATION AND DETAILS OF PILOT PLANT


MINISTRY OF THE ENVIRONMENT
POLLUTION CONTROL PLANNING BRANCH
WHITBY EXPERIMENTAL STATION
UNDERDRAINED FILTERS
GENERAL PLAN
OCT. 1974
FIG. No. 1
TO AJAX
VICTORIA ROAD W.
19.5
12.8
11.0
HOUSE No. 8
124.2
EXPERIMENTAL STATION CONTROL BUILDING (SEE FIG. 3 AND FIG. 4
17.7
FILTER BEDS
FILTER BEDS
0.06 PUMPING LINE
0.09 GRAVITY LINE
TILE FIELD
28.3
W.C.
HOUSE No.1
HOUSE No.2
HOUSE No.3
HOUSE No.4
HOUSE No.5
HOUSE No.6
HOUSE No.7
7.0
11.3
11.6
22.9
9.4
53.6
17.2
30.3
13.9
30.5
15.1
16.4
7.3
51.7
10.8
2.2
2 COMPARTMENT SEPTIC TANK & PUMP CHAMBER
0.14
M.H.1
M.H.2
M.H.3
M.H.4
M.H.5
M.H. 6
DISTRIBUTION CHAMBER
TO ONTARIO HOSPITAL
HOSPITAL ROAD
FARM ROAD
TO WHITBY & HWY. 401
LEGEND
M.H. MANHOLE
SEWER LINE
NOTE:
NOT TO SCALE
ALL MEASUREMENTS IN METRES


364
B
Z
A
A
191
354
364
191
1100
FILTER BEDS
FILTER BEDS
CONTROL BUILDING
COLLECTOR
DISTRIBUTER
91.4
182.8
91.4
60.9
121.9
121.9
60.9
505
330
305
B
- NOT TO SCALE
- ALL MEASUREMENTS IN CENTIMETRES
MINISTRY OF THE ENVIRONMENT
POLLUTION CONTROL PLANNING BRANCH
WHITBY EXPERIMENTAL STATION
UNDERDRAINED FILTERS
PLAN OF TREATMENT PLANT
OCT. 1974
FIG. 2


MINISTRY OF THE ENVIRONMENT
POLLUTION CONTROL PLANNING BRANCH
WHITBY EXPERIMENTAL STATION
UNDERDRAINED FILTERS
SECTION A-A
THROUGH TREATMENT PLANT
OCT. 1974
Scale in metres
140 LITRE OVERHEAD TANK
CONTROL BUILDING
DISTRIBUTION AND METERING BUCKETS
3.6m Not to scale
0.6 cm PLYWOOD
2.5 cm STYROFOAM INSULATION
5 x 10 cm STUDS
CRANE Cat 410 - 5 cm
"V" DETAILS OF VALVE OUTLET NOT TO SCALE
HOLDING TANKS
HOLDING TANKS
OBSERVATION WINDOW
9 cm DOMTAR PIPE
PIPE INSULATION
10 cm ABS TRIDON PIPE
FILL
FILTER MEDIA
SUPPORTS
60 cm
46 cm
2.3 m
0.6 m
1 m
1.2 m
75.0 cm
30 cm
15 cm
30.4 cm
2.5-4.0cm GRAVEL
PIPE INSULATION
1.9 cm PLYWOOD
9 cm DOMTAR PIPE
10 cm ABS TRIDON PIPE
FOR PLAN SEE FIG 5
3.3 m
3.7 m
3.1 m
3.1 m
COLLECTOR BUCKET
COLLECTOR BUCKET


LEGEND
A to I - DISTRIBUTION & METERING TANKS
1 to 6 - HOLDING TANKS
WINDOW
MINISTRY OF THE ENVIRONMENT
POLLUTION CONTROL PLANNING BRANCH
WHITBY EXPERIMENTAL STATION
UNDERDRAINED FILTERS
SECTION B-B
THROUGH TREATMENT PLANT
OCT. 1974
FIG No 4
5 0
Scale in Metres
OVERHEAD TANK
OVERHEAD TANK
FAN
DISCHARGE TO BUCKET
3.3 m
A
B
C
D
E
F
G
WASTE
I
2.54 cm PLASTIC PIPE
INCOMING SEPTIC TANK EFFLUENT
DISTRIBUTION AND METERING BUCKET
STYROFOAM ROOF INSULATION
3 HOLDING TANK
6 HOLDING TANKS 5
4 HOLDING TANK 1
43.2cm
44.6cm
43.2cm
44.6cm
49.2cm
44.6cm
STORAGE
TRIDENT 4cm
STYLE 3 METER
2.3 m
1.7 m
5.0 cm PLASTIC PIPE
1.2 m
11.0 m
INCOMING EFFLUENT LINE



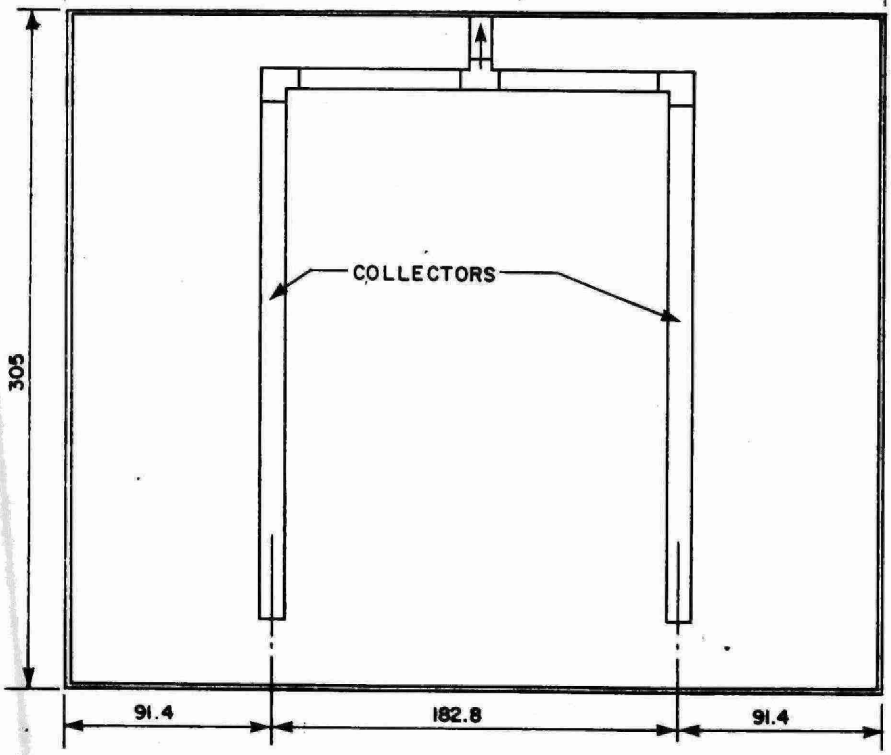

TYPICAL DISTRIBUTER LAYOUT

2cm PLYWOOD FRAME

NOTE:

NORTH SIDE - All pipes 10cm ABS Tridon, (perforate pipe inside the beds

SOUTH SIDE - All pipes 9cm Domtar, (perforated pip inside the beds).



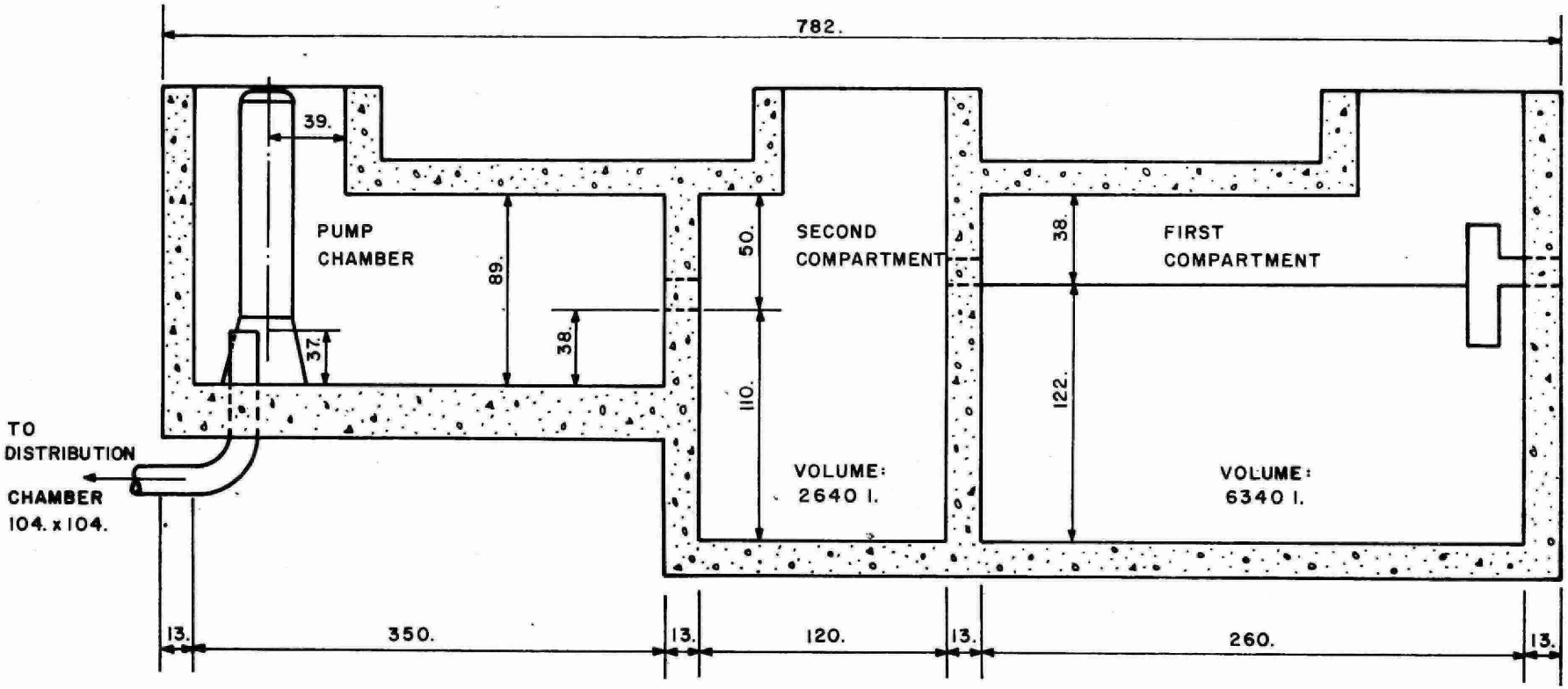

TYPICAL COLLECTOR LAYOUT

2cm PLYWOOD FRAME

- NOT TO SCALE

- ALL MEASUREMENTS IN CENTIMETRES

| MINISTRY OF THE ENVIRONMENT | |
|---|---|
| POLLUTION CONTROL PLANNING BRANCH | |
| WHITBY EXPERIMENTAL STATION UNDERDRAINED FILTERS | |
| DISTRIBUTER AND COLLECTO LAYOUT PLAN | |
| OCT. 1974 | FIG. 5 |



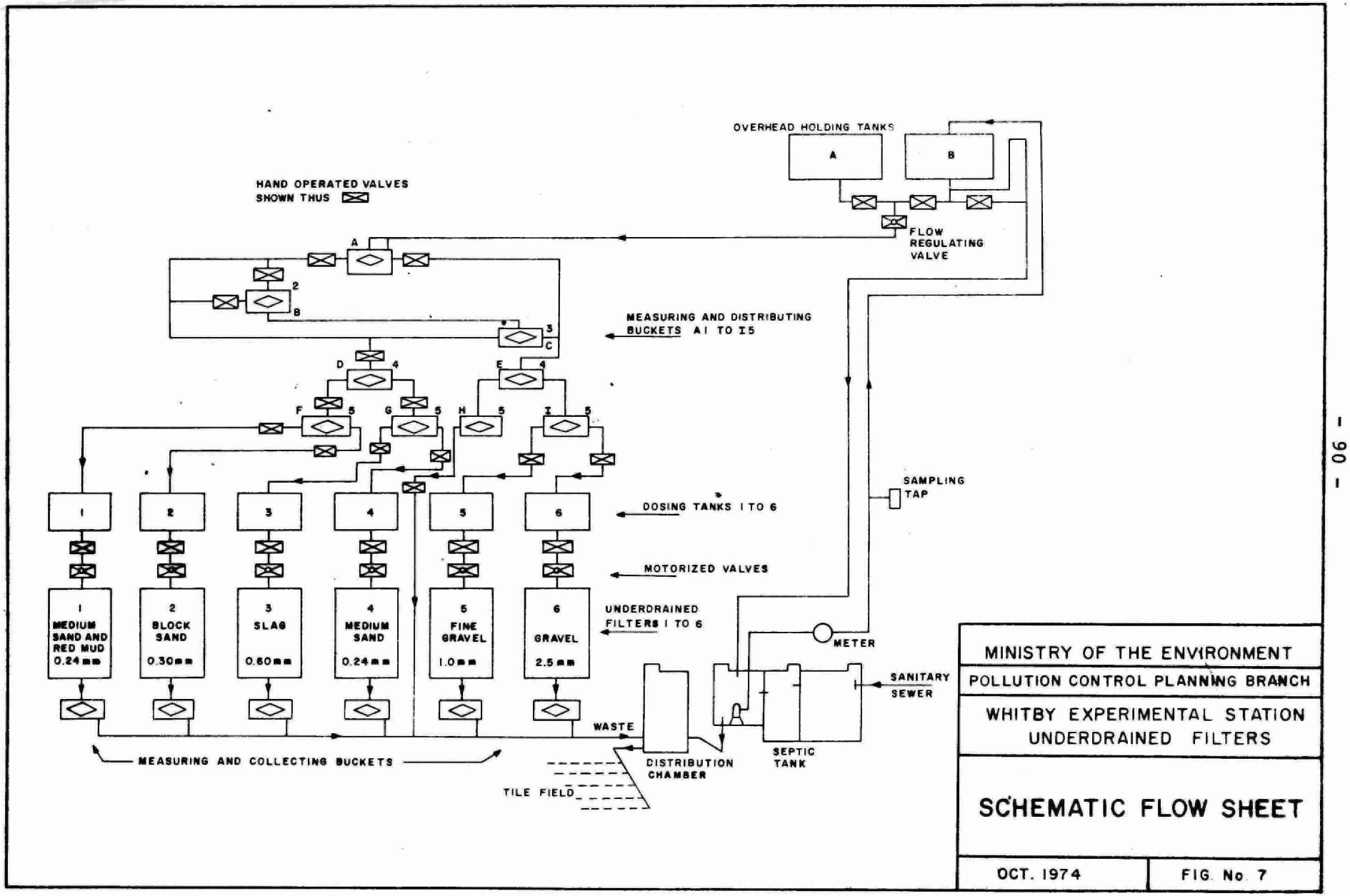

TANK WIDTH = 200. cm

NOT TO SCALE
ALL MEASUREMENTS IN CENTIMETRES

MINISTRY OF THE ENVIRONMENT
POLLUTION CONTROL PLANNING BRANCH
WHITBY EXPERIMENTAL STATION
UNDERDRAINED FILTERS

# SEPTIC TANK ELEVATION

OCT. 1974 | FIG. No. 6


OVERHEAD HOLDING TANKS
A
B
HAND OPERATED VALVES
SHOWN THUS
FLOW
REGULATING
VALVE
MEASURING AND DISTRIBUTING
BUCKETS A1 TO I5
SAMPLING
TAP
DOSING TANKS 1 TO 6
MOTORIZED VALVES
UNDERDRAINED
FILTERS 1 TO 6
METER
SANITARY
SEWER
1
MEDIUM
SAND AND
RED MUD
0.24 mm
2
BLOCK
SAND
0.30mm
3
SLAG
0.60mm
4
MEDIUM
SAND
0.24mm
5
FINE
GRAVEL
1.0mm
6
GRAVEL
2.5mm
WASTE
MEASURING AND COLLECTING BUCKETS
DISTRIBUTION
CHAMBER
SEPTIC
TANK
TILE FIELD
MINISTRY OF THE ENVIRONMENT
POLLUTION CONTROL PLANNING BRANCH
WHITBY EXPERIMENTAL STATION
UNDERDRAINED FILTERS
SCHEMATIC FLOW SHEET
OCT. 1974
FIG. No. 7



DWG. Nº 5316

# APPENDIX III

## EFFECT OF RED MUD ON REMOVAL OF PHOSPHORUS FROM DOMESTIC SEWAGE

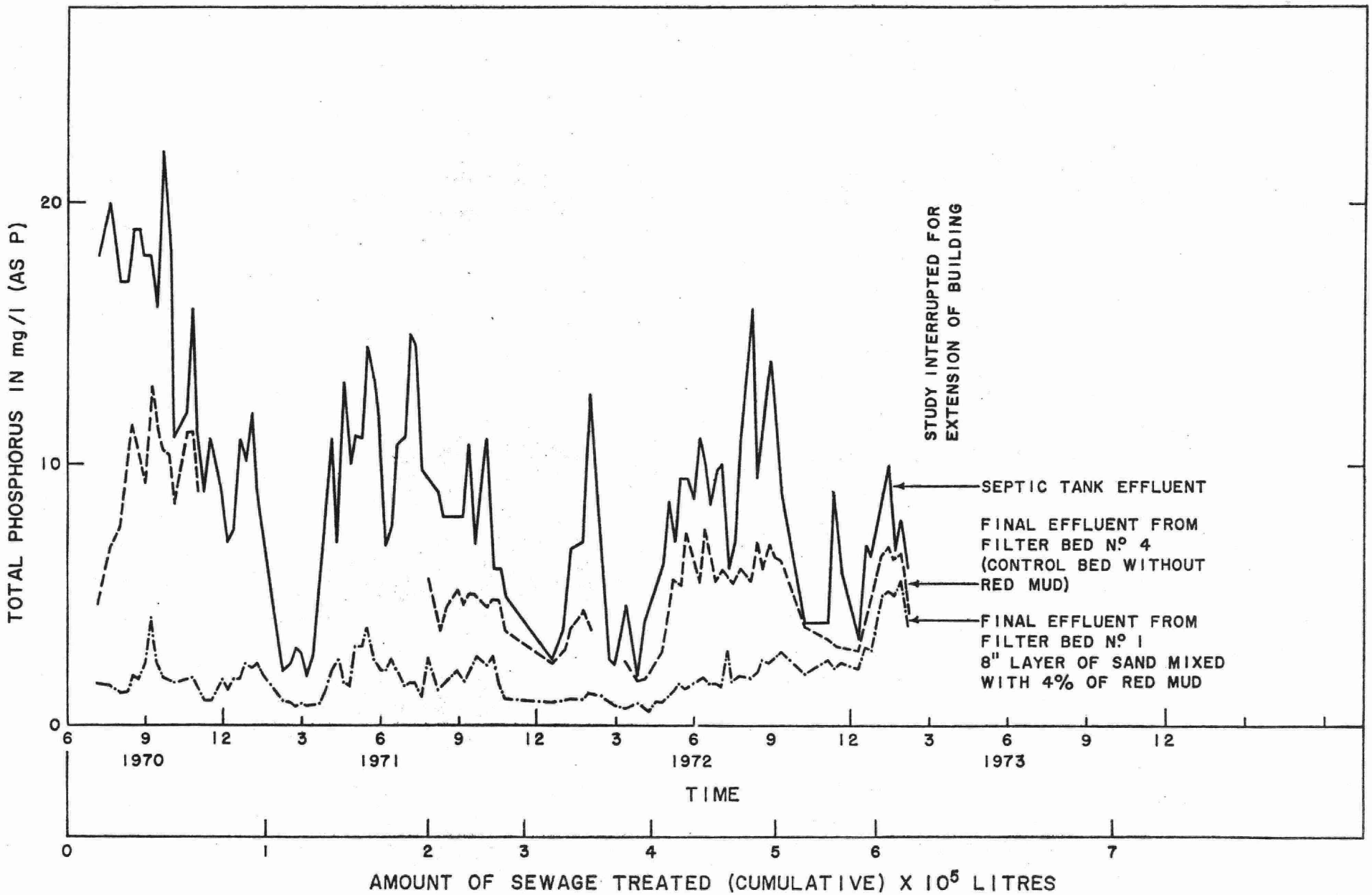



FIG. 7 – EFFECT OF RED MUD ON REMOVAL OF PHOSPHORUS FROM DOMESTIC SEWAGE

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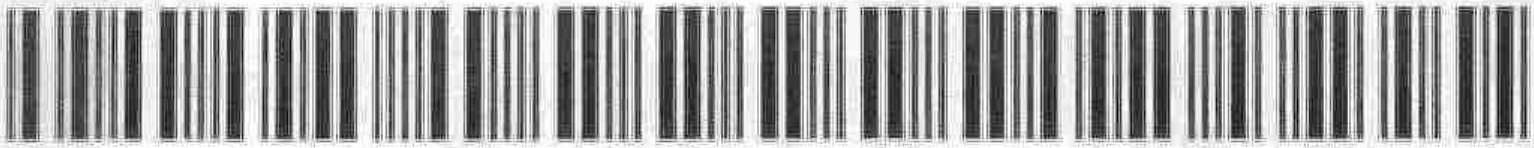
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